Lake Erie Fisheries Assessment Unit
Report 1987-3

# A TWELVE YEAR STUDY OF THE FISH COMMUNITY IN THE NANTICOKE REGION OF LONG POINT BAY, LAKE ERIE:

## 1971 - 1983 SUMMARY REPORT

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# ACKNOWLEDGEMENTS

This report is the culmination of some 16 years of data collection and analyses which, at last count, represents the efforts of some 40 different professional, technical, clerical and summer staff between 1970 and 1986. We wish to express our sincere appreciation to these individuals and to recognize their efforts on the first pages of this document. We readily acknowledge that our efforts in preparing this document would be small when compared to the collective endeavours of the many other individuals who participated in the Nanticoke Fish Studies since 1970. Far too frequently the efforts of such individuals disappear between the lines of a final report and we recognize that this report is no exception. To these people we apologize for this failing and ask them to accept this written acknowledgement as a small token of our understanding and appreciation for their diligent work. In this report we pay special tribute to those who have worked with us in the latter study years (1980-1986).

First, we salute Captain Harold (Harley) Powell, who remained at the helm of our vessel the DAVID-M since 1970 and survived the entire project. He alone has seen and been instrumental in the project from beginning to end, and for that he attains special status. His steadfast attention to seamanship, gear and vessel maintenance, training technical staff, and attention to detail provided stability and a thread of consistency essential to a project of this nature. Mr. James A. Murphy co-ordinated and participated in field and laboratory technical activities from 1980-1983, and his special attention to safety, vessel upgrading and facility development were appreciated by all who worked here. The combined technical fisheries

experience of these two individuals exceeds sixty years; their gruff ability to train biologists in the fine art of technical reality (while at times humbling) clearly influenced us in a positive fashion and will always be appreciated.

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Excellent past contributions by technicians Stan Powell (1980-1982) and John Mulholland (1980-1982), who have since moved on to other work, are nonetheless remembered and appreciated as are those of the many summer students, including Mike Mitchell, Mary Cassidy, Wendy Guiler and Tina Taylor.

With so many individuals contributing to the earlier (pre-1980) study years we cannot adequately acknowledge all by name here. Certainly the efforts of past project directors John Kelso, Geza Teleki and John Hamley deserve special acknowledgement here, as only those directly involved in the project can adequately appreciate their contributions. Other individuals such as N. MacLean, L. Sztramko, J. Grant, T. Howley and J. Lipsit contributed strongly to the project in those years. Clearly these individuals set the scene for our 1980-1983 efforts and to them we owe special thanks, while appologizing for any mistakes or misrepresentations of their work that we may have made. Mr. J. Paine (OMNR) provided strong technical and moral support for us throughout the 1980-1986 period and exhibited exemplary patience as he struggled through each fiscal year with us. Mike Petzold (OMNR) and Mrs. Jeannette Hines (University of Guelph) provided excellent advice and support concerning the many computing and statistical matters that arose throughout our analyses.

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Up to and including 1983, funding was provided jointly by Ontario Hydro, Steel Company of Canada, Texaco Canada and the Ontario Ministry of Natural Resources. Funding from 1984-1986 was provided entirely by the Ontario Ministry of Natural Resources. The members of the NEC and Nanticoke Technical Comittee were generous with their ongoing support and counsel, and deserve our sincere thanks.

# 1.0 INTRODUCTION

## 1.1 NANTICOKE ENVIRONMENTAL COMMITTEE

A major industrial complex, which uses Long Point Bay on Lake Erie as a water supply and waste receiver, has developed in the Nanticoke area (Figures 1.1-1, 1.1-2) since the late nineteen sixties. This complex was the first large industrial development on the Canadian side of Lake Erie and includes Ontario Hydro's 4000 MW coal-fired thermal generating station, a 105,000 barrel-per-day oil refinery (Texaco Canada Inc.), and an integrated steel mill and industrial park with an initial capacity of 1.17 million tonnes of steel annually (Stelco Inc.).

When Ontario Hydro announced construction of its thermal generating station in 1968, the Nanticoke Environmental Committee (NEC) was formed. The committee now combines the technical and financial resources of all three industries and government (Ontario Ministry of the Environment and Ontario Ministry of Natural Resources) in co-ordinating investigations of the aquatic environment in the Nanticoke area of Long Point Bay. The basic objective of the NEC studies was to establish whether the industrial complex affected the aquatic environment and to recommend, if required, appropriate mitigative action. The present program includes studies of the physical and chemical aspects of water quality, and of selected biological components of the aquatic community. The scope of the field program and the agencies responsible were as follows:

| | |
|---|---|
| Temperature: | Ontario Hydro |
| Currents: | Ontario Hydro and Ministry of the Environment |
| Water Quality: | Ministry of the Environment |
| Phytoplankton: | Ministry of the Environment |
| Zooplankton: | Ministry of Natural Resources |
| Benthos: | Ministry of the Environment |
| Macrophytes: | Ontario Hydro |
| Fish: | Ministry of Natural Resources |

Baseline studies were launched in 1967-69, to describe existing conditions prior to industrial development. By 1978 these studies had come to a transition, as the period of minimal industrial influence was ending. The Nanticoke Thermal Generating Station (NTGS), consisting of eight 505 MW units, was approaching full capacity (the first unit was commissioned in 1973 and the last in 1978); while Texaco's refinery and Stelco's steel mill became operational in 1978 and 1980 respectively. Field studies were stopped temporarily in 1979, to enable all agencies to prepare reports on data collected to 1978, but were reactivated in 1980 to monitor operational conditions. The operational study period (1980-1983) has included years when all industries were operating, but, with the exception of the NTGS, none approached full capacity.

## 1.2 NANTICOKE FISH STUDY

This report summarizes a long term (1971-1983) monitoring study of the Long Point Bay fish community in relation to the development of heavy industry (Stelco Steel Mill, Nanticoke Thermal Generating Station, and Texaco Refinery) on the north shore. Recognizing that protection of the Long Point Bay fish community would be of immense importance in the face of shoreline industrialization, the Nanticoke

Fish Study (NFS) was launched by the Nanticoke Environmental Committee in the spring of 1971 to:

i) describe and monitor the composition, distribution and abundance of the fish community in the Nanticoke area of Long Point Bay;

ii) examine movement and migratory patterns of selected fish species;

iii) examine selected aspects of fish biology (age, growth, feeding, reproduction) for several locally important fish species; and

iv) identify changes in the above parameters in response to industrialization.

The NFS headquarters were in Port Dover, Ontario; administered by OMNR, and jointly funded by industry and government until 1984. From 1984 to present, all funding was provided by OMNR. In 1980, the NFS became a sub-unit of the Lake Erie Fisheries Assessment Unit (OMNR) headquartered in Wheatley, Ontario. By 1981 two permanent staff and up to 11 seasonal staff were based in Port Dover.

The underlying approach to NFS investigations (and indeed all NEC studies) was similar to that of other projects designed within the same time frame (eg. see Merriman and Thorpe 1976, and Hesse et al 1982). By establishing baseline (preoperational) conditions of various fish community parameters, and subsequently monitoring these parameters as industry developed and became fully operational, it was anticipated that preoperational conditions when compared with operational conditions would enable detection of change due to industrial development. In addition, reference or "control" locations would be compared to "test" locations within immediate influence of industrial effluent.

By adopting this long-term approach, which is designed to detect departures from "normal" conditions, we experienced difficulties similar to those described by Schlesinger et al. (1982). First, it was assumed that "normal" conditions could be determined, and that normal conditions would be those measured in the preoperational period. However, we encountered very high variability in most parameters measured and unexpectedly high mobility of many adult fish species. Moreover, the large, evolving commercial and sport fisheries in Long Point Bay must impose strong but changing forces on several key fish populations in the area. Thus, "normal" conditions in the operational period likely were very different from those in the preoperational period for reasons other than industrial inputs. It has become quite clear, therefore, that only marked changes attributable to industry could be detected.

Secondly, the long-term, rather large scale nature of the project led to other complicating forces external to strictly biological issues "not the least of which is the change resulting from personnel turnover" (Schlesinger et al. 1982). The study understandably evolved through the years. The project was modified, procedures improved and components added or deleted as time progressed and information accumulated. By 1974, the study area was more sharply focused to Nanticoke waters, rather than attempting to monitor all of Long Point Bay.

The work carried out by NFS to 1978 has been described in various reports (Kelso 1972, 1973a; Teleki 1973, 1976, Teleki et al. 1977, Hamley 1981). Our field investigations (1980-1983) encompassed what is loosely considered the "operational" years, although most industries had not yet reached full operation. In this period, we attempted to maintain the status quo regarding field and laboratory methodology to enable good comparison with the earlier years. The maintenance of consistency was strongly emphasized in the 1980-1983 period despite some reservations about past techniques and the looming temptations to change or improve. The only important changes made to the program were the initiation of some new studies, designed to provide specialized information, or sample sizes were increased in such a way that comparisons with past years could still be made while providing a stronger data base in the likely event that future studies will be carried out.

New programs were added between 1978 and 1980 to focus more closely on the waters in the immediate vicinity of discharge from the industries. At Centre Creek (receiving stream for Stelco's effluent) we added larval fish and adult fish monitoring programs in 1978 and 1980, respectively, which were not expected to produce any conclusive results by 1983, but were intended to provide data which could be used for reference in future studies. A creel census program at the NTGS thermal plume was added in 1982 to provide information concerning the growing sport fishery in these waters, and additional information concerning the adult fish inhabiting the plume waters. We also made several attempts to examine fish spawning activities in both discharge areas but were only moderately successful.

In this report we not only describe the results of our 1980-1983 studies, but also have included all comparable data from 1971 onward to provide a comprehensive evaluation of the Long Pont Bay fish community in response to industrial development. Wherever possible, we have examined our data in comparison with those collected elsewhere in Lake Erie to assist us in determining whether changes detected at Nanticoke were specific to our study area, or were reflections of lake-wide trends. As this is the final report planned for the study under NEC direction, we decided to produce a comprehensive resource document, which includes a considerable number of tables and figures so that as much data as possible would be available in one complete report. We did so with the full expectation that additional work will be carried out at some future time at Nanticoke. Our past experiences demonstrated that a complete working document in this form would be of most benefit to such studies. Moreover, as considerable information concerning local fish populations in Long Point Bay is available in this report, these data may be valuable as reference material for other future issues concerning the fishery.

## 1.3 INDUSTRIAL DEVELOPMENT

Detailed descriptions of the industries and their respective pollution control systems can be found in Weiler and MacGregor (1985) and Jeffs (1981). The following is a brief synopsis of these descriptions.

### A. Nanticoke Thermal Generating Station

At full capacity, the NTGS consumes some 35,000 Mg of coal per day. The principal emission to the aquatic environment is heated condenser cooling water. The cooling water is drawn from a forebay at a rate of some 88 $m^3/s$ through two submerged intakes located about 550 m offshore in 10 m of water (Figure 1.1-2).

Until 1983, a maximum temperature rise (ΔT) of 8.3°C was permitted across the station (intake to outfall). Eight tempering pumps, each with capacities of 8 $m^3/s$, are available to draw ambient water from the forebay into the discharge channel to temper the heated condenser cooling water (62 $m^3/s$ maximum). In addition, water from the intakes is used to supply water to neighbouring communities, for boiler make-up and for fly and bottom ash disposal. At maximum flow, up to 154 $m^3/s$ of water may be drawn through the intakes (in 1978 some $2.5 \times 10^9$ $m^3$ of water were used by the NTGS; Hamley 1981).

In warm weather, the thermal plume produced from the discharge of heated water into the cooler lake usually floats. A buoyant warm layer about 3 m thick and extending some 2-3 km from the discharge channel is formed, mixing to the lake bottom only within a few hundred meters of the discharge channel. In winter, the plume typically is uniform in temperature from surface to bottom, extending some 500-1000 m from the channel. Examples of thermal plumes at Nanticoke are depicted in Figure 1.3-1.

In June of 1983, the maximum ΔT was increased to 12.5°C by special permit, enabling Hydro to substantially reduce tempering (and thus intake water volume) for a 5-year experimental period. Studies relating to potential environmental costs and benefits of reduced tempering are currently under way by Ontario Hydro scientists.

B. Stelco Steel Mill (Lake Erie Development)

The initial phase of Stelco's steel mill will have a production capacity of 1.17 million tonnes of steel. It comprises a dock for receiving iron ore and coal, a coke oven battery, a two-vessel basic oxygen steelmaking shop, a continuous slab casting machine, and a hot strip rolling mill. The coke oven began operation in 1981 and the hot strip mill in 1983.

Process water is treated, stabilized in a final settling pond (Pond No. 4: 7 day retention) and then discharged to the lake via Center Creek. The effluent satisfies end of pipe objectives as well as the Provincial Water Qualtiy Objectives at the edge of a 120 ha limited use zone at the mouth of Centre Creek.

### C. Texaco Refinery

This refinery, capable of handling 105,000 barrels of crude oil per day, is designed to produce a variety of domestic and industrial fuels, including leaded and unleaded gasoline, aviation and diesel fuels, liquified propane and butane and, as a by-product, liquid sulphur. Because air is used for 85% of the refinery's cooling requirements, only 460-650 $m^3$/day of cooling water is used. The discharge into Lake Erie is through a diffuser located some 130 m offshore in the NTGS plume at a depth of 7 m (Figure 1.1-2). The effluent is one of the cleanest of refinery discharges in Ontario, meeting provincial quality guidelines as well as Environment Canada's loading criteria.

### D. Progress of Industrialization

Commissioning of the three plants has been much slower than was anticipated at the beginning of the various NEC studies. While all NEC field studies ended in 1983, only the Texaco Refinery and the Nanticoke Thermal Generating Station approached full operation by that time. The Stelco Steel Mill only recently started operation of its hot strip mill (1983), and the coke ovens were not fully operational until 1982. Our studies have not encompassed periods of strong operation from all industries; however, for the purpose of most NEC studies, the data have been grouped into the following three periods: Baseline (1973 and earlier), Commissioning (1974-1978) and Operational (1980-1983).

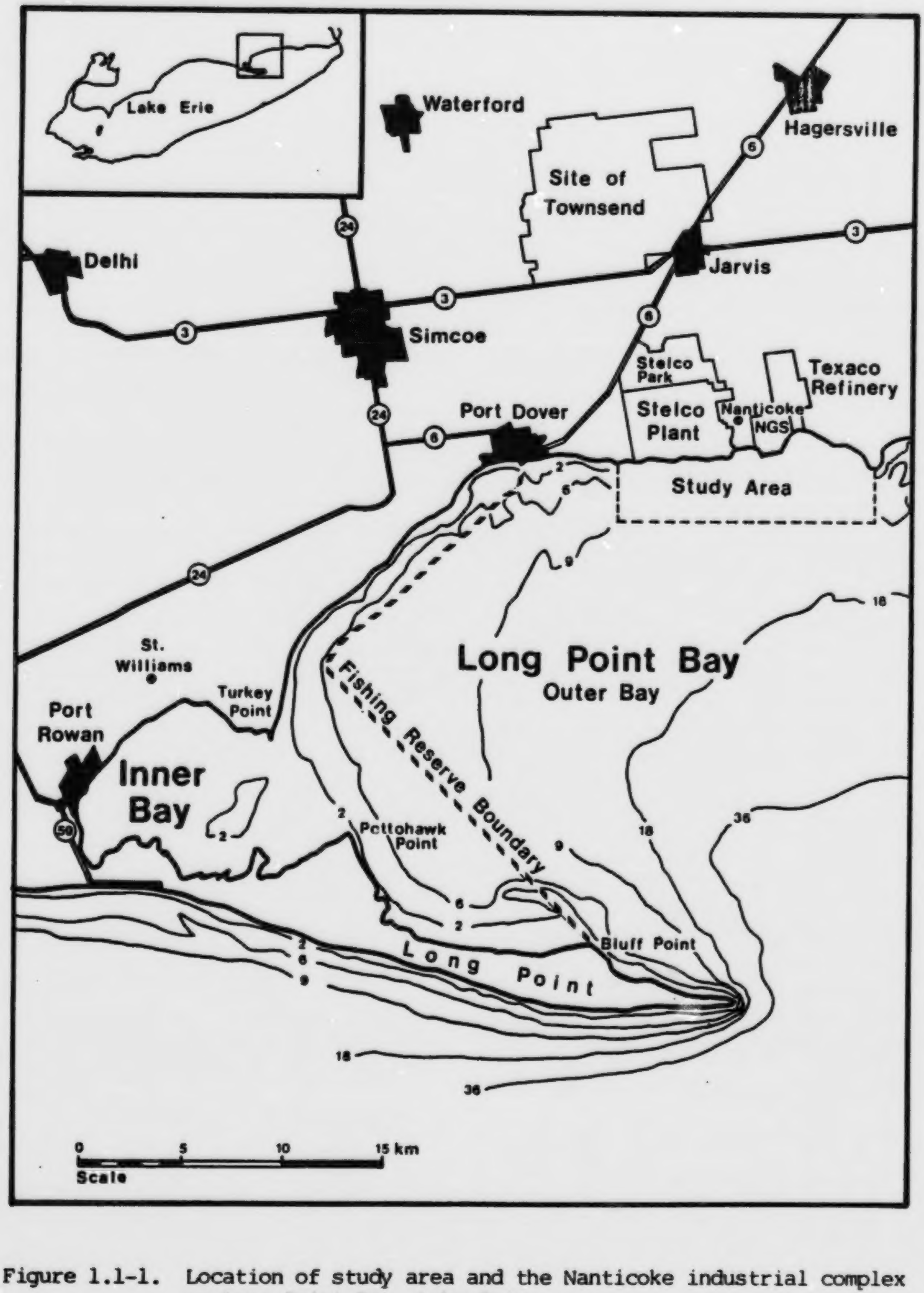
Lake Erie
Waterford
Hagersville
Site of Townsend
Delhi
Jarvis
Simcoe
Stelco Park
Texaco Refinery
Port Dover
Stelco Plant
Nanticoke
NGS
Study Area
St. Williams
Turkey Point
Port Rowan
Inner Bay
Long Point Bay
Outer Bay
Fishing Reserve Boundary
Pottohawk Point
Bluff Point
Long Point
0
5
10
15 km
Scale

Figure 1.1-1. Location of study area and the Nanticoke industrial complex on Long Point Bay, Lake Erie.

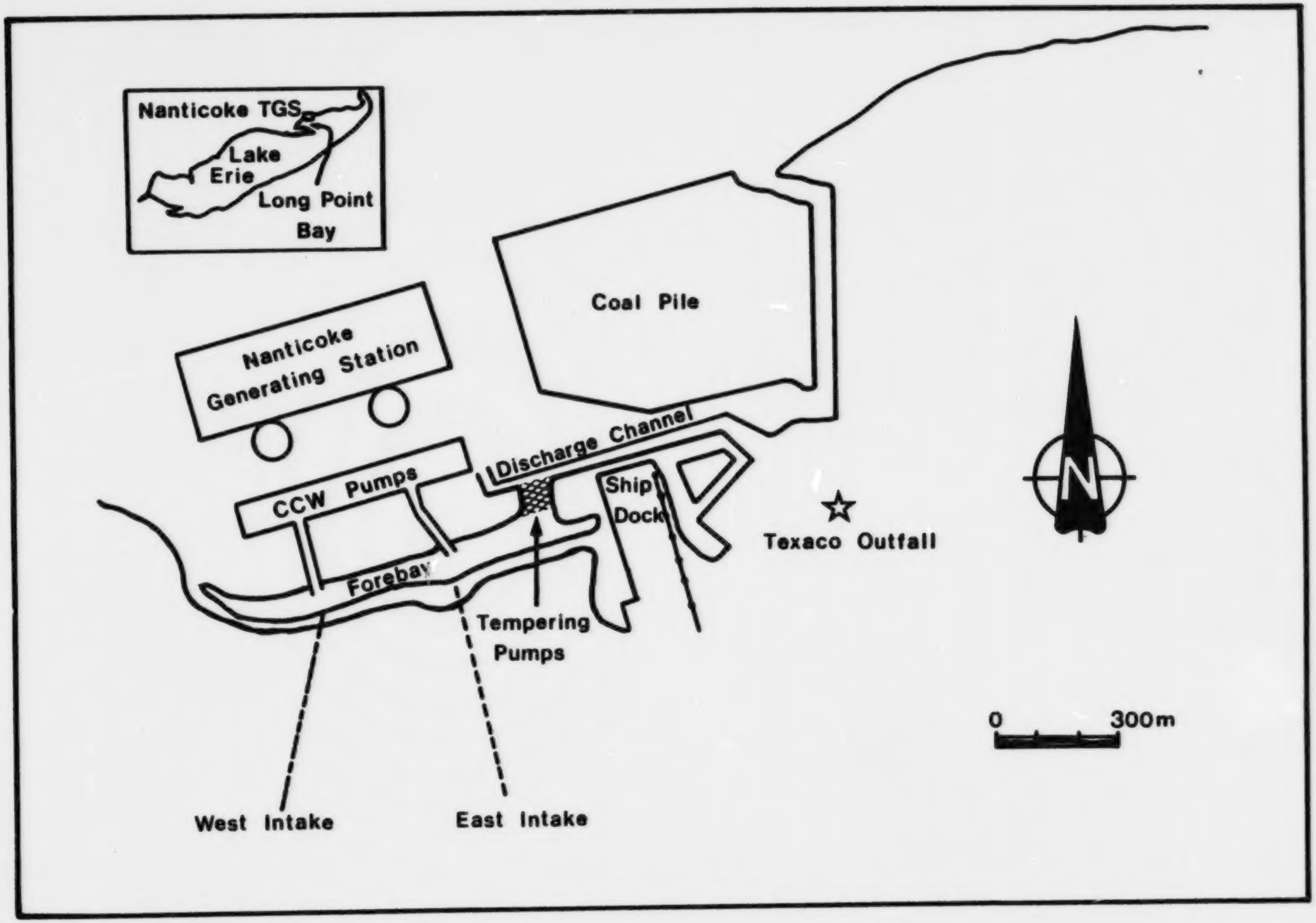
Nanticoke TGS
Lake
Erie
Long Point
Bay
Nanticoke
Generating Station
Coal Pile
Discharge Channel
CCW Pumps
Ship
Dock
Texaco Outfall
Forebay
Tempering
Pumps
N
0
300m
West Intake
East Intake

Figure 1.1-2. Nanticoke Thermal Generating Station

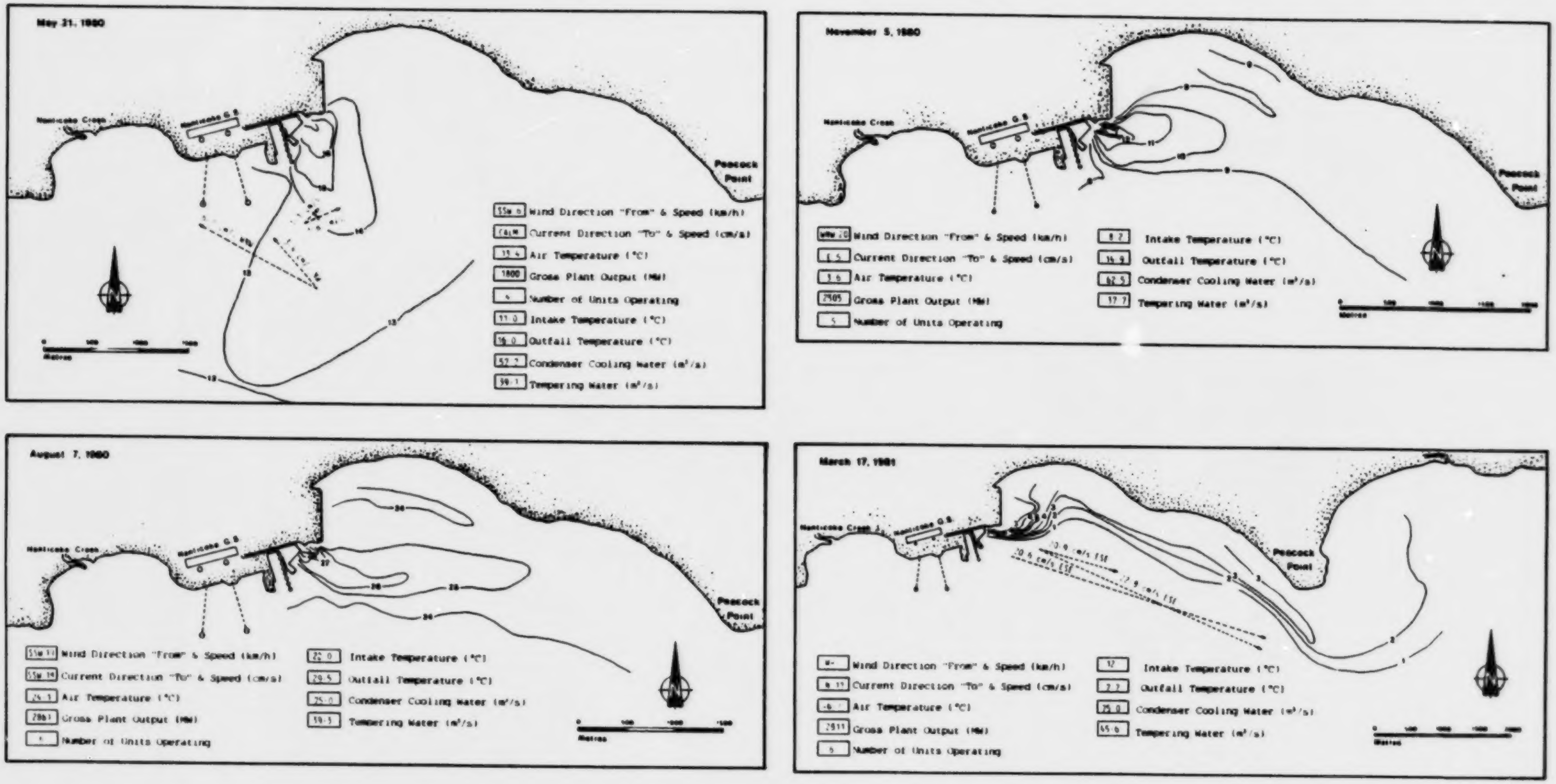
May 21, 1980
November 5, 1980
August 7, 1980
March 17, 1981
Nanticoke Creek
Nanticoke G.S.
Peacock Point
Wind Direction "From" & Speed (km/h)
Current Direction "To" & Speed (cm/s)
Air Temperature (°C)
Gross Plant Output (MW)
Number of Units Operating
Intake Temperature (°C)
Outfall Temperature (°C)
Condenser Cooling Water (m³/s)
Tempering Water (m³/s)
Metres

Figure 1.3-1. Surface water temperatures at Nanticoke measured during thermal plume investigations, May 1980 - March 1981. After Metcalfe (1982).

# 2.0 STUDY AREA

## 2.1 GENERAL DESCRIPTION

### 2.1.1 Lake Erie

Lake Erie is the southernmost, shallowest and most productive of the Great Lakes with a surface area of 25,600 km$^2$ 12,820 km$^2$ within Canadian boundaries) and a volume of some 480 km$^3$. The lake exhibits a maximum length of 390 km and an average width of 70 km (mid-lake maximum of 92 km). Several features of its bathymetry divide the lake naturally into three rather distinct basins: Western, Central and Eastern (Figure 2.1.1-1).

The Western Basin comprises 13% of the surface area of Lake Erie, and is a shallow plateau with depths usually less than 11 m. It is separated from the Central Basin by an escarpment which extends from Point Pelee, Ontario to Marblehead, Ohio. This basin exhibits eutrophic conditions: phytoplankton biomass concentrations average 5.3 g/m$^3$ (Sly 1976) and sediment oxygen demand rates (5 min) have averaged 400 to 600 mg/g of sediment (Beeton 1969). Total annual precipitation is lowest here, averaging 82 cm.

Representing 63% of Lake Erie's total surface area, the Central Basin is somewhat deeper (<25 m) and is separated from the Eastern Basin by a sand and gravel ridge that extends south from the base of Long Point, Ontario to Erie, Pennsylvania. The basin generally exhibits limnological features characteristic of mesotrophic lakes. The western half of the basin has shown sediment oxygen demand rates ranging from 200 to 600 mg/g, while the eastern half ranges from 25 to

400 mg/g (Beeton 1969). Average phytoplankton biomass concentrations reach 3.2 $g/m^3$, and annual total precipitation averages 89 cm (Sly 1976).

The Eastern Basin accounts for 24% of the surface area, and is the deepest of the three basins, reaching a maximum depth of 64 m off the tip of Long Point. Sediment oxygen demand rates have been lowest in this basin at 50 - 400 mg/g of sediment (Beeton 1969). Phytoplankton biomass concentrations are also lower in the Eastern Basin than elsewhere in Lake Erie, averaging 2.4 $g/m^3$. Highest annual precipitation occurs over this basin, averaging 92 cm (Sly 1976).

For management purposes, the waters of Lake Erie have been divided into Statistical Districts on both the Canadian and U.S. sides (Figure 2.1.1-2A; Smith et al. 1961), and in recent years international management units also have been developed (Figure 2.1.1-2B; Baker et al. 1985).

### 2.1.2 Long Point Bay

Long Point Bay (42° 37' N latitude, 80° 10' W longitude) is situated on the north shore of the Eastern Basin within Statistical District 4 (OE-4). The bay is partially enclosed by a long sand spit (known as Long Point) that curves southeastward from the north shore. Inner Bay (7800 ha), an enriched and shallow (mean depth = 1.0 m) water body situated near the base of Long Point, is separated from the deeper Outer Bay by a partially submerged sandy shoal, and by a second, smaller sand spit (Turkey Point) extending in a north to south direction (see Figures 1.1-1 and 2.1.2-1A).

The north shore of Long Point Bay is formed by the Norfolk Sand Plain and the Haldimand Clay Plain. Bedrock of the Delaware formation is overlayed by silt, clay or boulder clay, and the upper strata are comprised principally of Norfolk sand (Whillans 1977). The bottom deposits of the bay consist of rock and sand nearshore, grading to sandy muds and muds further offshore. Nearshore sediments in the Outer and Inner Bays are comprised of about equal parts sand, silt and clay, while sediments from the center of the Outer Bay consist of less sand (5-20%) and more silt (40-60%), the remainder being clay (Figure 2.1.2-1B). Although several small coldwater streams drain into Long Point Bay, Big Creek is now the largest contributor to Long Point Bay's watershed, and muds are constantly accumulating at its mouth, creating a deltaic deposit in the western portion of the Inner Bay.

Recent reviews of the water quality of Long Point Bay have been carried out by Weiler and Heathcote (1979), Heathcote et al. (1981), Leach (1981) and MOE (1986). The Inner Bay has been classified as eutrophic (Leach 1981) and the Outer Bay as oligomestrophic to mesotrophic (Leach 1981, Heathcote 1981, MOE 1986). The water quality of outer Long Point Bay has been described as the best in nearshore Lake Erie (Heathcote 1981).

The shallow shores of outer Long Point Bay and Inner Bay are strongly affected by fluctuations in water levels, and long-term changes in water levels affect the growth and degeneration of the ecologically important marshes, which are particularly extensive within the Inner Bay and along Long Point. Seasonal fluctuations in water levels of some 30 cm are common; wind-induced seiches occur frequently and can cause fluctuations of 30 cm or more in a few hours.

### 2.1.3 Nanticoke Study Area

While the original study area encompassed virtually all nearshore areas of Long Point Bay (Kelso 1972), the study area was reduced in 1974 to encompass only those waters in the immediate Nanticoke area (Figure 1.1-1 and 2.1.3-1). Descriptions of currents, water chemistry, temperatures, and other abiotic and biotic parameters at Nanticoke are available in Weiler and MacGregor (1985) and references cited therein. In general, however, water circulation is predominately parallel to the shore and, during summer, currents are generally to the east (frequency about 43%). Water temperatures typically follow air temperature and, because of the shallowness of the study area, increase at a rate of about 5°C/month in the spring. A maximum of about 25°C is reached in August and water temperatures decline rapidly to about 5°C by November. Thermal stratification develops periodically but it is not permanent; mixing to the bottom occurs frequently. Several upwelling events occur each year between April and November, bringing colder, nutrient-enriched and oxygen-depleted water close inshore.

Nearshore sediments at Nanticoke vary along the shoreline and are comprised of bedrock, rock, sand, silt or clay (Figure 2.1.3-1). Site-specific descriptions of bottom sediments and general habitat conditions at Nanticoke are described as required within subsequent sections or chapters of this report.

## 2.2 FISHERIES

Lake Erie supports some 138 predominantly warmwater and coolwater fish species and, despite such strong cultural stresses as exploitation, pollution and eutrophication, it remains the most productive of the Laurentian Great Lakes in terms of fish harvest (Leach and Nepszy 1976). The fleet of some 150 vessels is considered to be the largest freshwater commercial fishing fleet in the world (Kendall et al. 1977). More than 35 species have been utilized by the commercial fishery since it began in 1795, and at least 19 of these species have been significant in the landings at one time or another (Hartman 1972, Leach and Nepszy 1976).

Historically, the lake whitefish was the most valued and sought after species in Lake Erie, although lake herring and lake sturgeon were also heavily exploited in the early years. While percids (walleye, yellow perch, sauger) were not highly prized in the early fishery, the blue pike was the most highly valued species of this group (Smith 1972). Since the virtual disappearance of highly valued species in Lake Erie (lake trout, lake whitefish, lake herring, blue pike) there has been a marked increase in commercial production of such species as yellow perch, white bass, and rainbow smelt. Walleye have made an important contribution to the commercial fishery of Lake Erie for many years (Nepszy 1977), particularly in the Western Basin.

In the early years yellow perch were of so little value that they were rarely mentioned in reports or listed in the catch (Smith 1972); however, Canadian harvests increased in the late 1950's and 1960's due to the presence of a number of strong year classes, the lack of other marketable species, increasing use of nylon gill net, and increased effort (Nepszy 1977).

Rainbow smelt are not native to Lake Erie, but were first reported in the lake in 1935 (Van Oosten 1937). A notable population existed in Lake Erie by the early 1950's and, with the development of commercial trawling and the availability of a market, commercial harvest of this species increased markedly and has remained relatively stable since that time (Leach and Nepszy 1976).

Although at least 23 species of fish are harvested presently from Lake Erie, yellow perch, rainbow smelt, walleye and, to a lesser extent, white bass are now the mainstays of the commercial fishery. Commercial fish landings in Lake Erie amounted to 16.3 million kilograms, valued at 26.3 million dollars in 1984 (OMNR 1985).

Today, as in earlier years, a thriving commercial fishery persists in Long Point Bay and is of utmost importance to the local economy. The Outer Bay fishing fleet of modern smelt trawlers and perch gillnetters is based in Port Dover and accounts for most of the smelt harvested in Lake Erie. More than 90 vessels operate in this manner in the Outer Bay and in 1983 some 10.7 million kilograms of fish, including 10.2 million kilograms of smelt and 141.9 thousand kilograms of yellow perch were harvested in these waters (Stat. Dist. OE-4). The landed value of this harvest amounted to 3.5 million dollars (OMNR 1984). Smelt harvests from Long Point Bay (OE-4) in 1983 accounted for approximately 78% of the total Lake Erie harvest. In addition to the large Outer Bay fishery, the Inner Bay supports a small commercial fishery of about 30 licensed hoopnetters and seiners who take a variety of species, including northern pike, yellow perch, crappies, bullhead and carp in the spring and fall of each year.

Intended principally to minimize the incidental catch of sport fish and conflicts with recreational use of Inner Bay - Long Point waters, gill nets and trawls are restricted to Outer Bay waters west of the line illustrated in Figure 1.1-1. Waters west of this line are referred to as the restricted zone and the line is termed the Fishing Reserve Boundary. For the same general reasons, hoop and seine nets are prohibited from the restricted zone between May 13 and August 31 of each year. Recently, the Ontario Ministry of Natural Resources developed a quota system for commercial fishing on the Great Lakes wherein the Province assigns individual commercial species quotas on a lake by lake basis. Initial sharing of the resources among commercial fishermen are determined by a provincial formula (based on past performance) and/or prior arrangements negotiated by the industry.

In addition to the important commercial fishery, Long Point Bay supports one of the best sport fishing areas in southern Ontario and it is still labelled by some as "Ontario's best known smallmouth bass hole". Up to 7,000 anglers can be expected on Long Point Bay on opening day of bass fishing, and some 200,000 to 300,000 rod-hours of angling effort are expended by anglers each summer in pursuit of primarily smallmouth bass. Although less desirable, yellow perch and rock bass are the two species most frequently caught by anglers during the summer months. Total summer sport fish harvests on Long Point Bay in recent years have ranged between 150,000 to 280,000 fish (all species) of which approximately 95% were yellow perch, smallmouth bass, and rock bass. Some 15 other species make up the remaining summer sport fish harvest.

An important winter ice fishery exists on Inner Bay near St. Williams. Approximately 100 huts are offered for rent each winter (two commercial operators account for 75 of them); in addition, several hundred private huts are erected, and many parties fish out in the open. Duration of the winter sport fishery and total fishing pressure are influenced primarily by ice-conditions. Fishing effort is directed almost exclusively towards yellow perch, although small numbers of rainbow smelt and northern pike are also taken. In recent winters when suitable ice conditions existed, total fishing pressure ranged between 47,000 (1980) to 127,000 (1979) rod-hours. In 1979, an estimated 315,000 yellow perch (or about 31,500 kg) were taken through the ice by anglers. By comparison, 147,000 kg of perch were harvested commercially from Long Point Bay and adjacent waters (OE-4) in that year (Hamley 1981).

In addition to the above mentioned major summer and winter sport fisheries in Long Point Bay, several other smaller fisheries exist, including a spring fishery for rainbow smelt along the beaches of Long Point Bay and the spring fishery for northern pike in the Crown and Big Creek marshes. Both of these species are taken during their spring spawning runs principally by seines or landing nets in the case of smelt, and by spearing in the case of pike. Estimated catches of pike by spearing in Long Point Bay have ranged from between 1,100 to 5,600 in 1975 and 1977.

An unknown, but presumably small amount of natural recruitment originating from a few select coldwater streams in Long Point Bay has helped support a highly prized sport fishery for trout and salmon in this area. The catches can consist of brook trout, brown trout, rainbow trout, coho salmon and chinook salmon. Angling for salmonids on the Bay is concentrated near the mouth of tributaries in spring and fall, and more recently in the deep offshore waters near the tip of Long Point during summer. In 1979, pink salmon became established in Long Point Bay for the first time and may also be caught during their fall spawning run.

A notable sport fishery has developed recently on the heated discharge waters of the Nanticoke Thermal Generating Station. Several fish species are attracted to the warmwater discharge, particularly during the spring spawning season. Anglers have experienced tremendous success fishing for white bass (up to 30 white bass/rod hour) in the plume during May and June when densities of this species are highest. Fishing opportunities for smallmouth bass and yellow perch can be excellent here, and the occasional walleye and salmon are taken also.

Melski (1972) estimated that the replacement value of the Long Point Bay sport fishery to anglers was approximately 4 million dollars. This excludes the substantial economic benefits that the fishery generates to the local economy. Because of its close proximity to major urban centres, the significance of the fishery can be expected to increase in light of escalating energy costs and other major changes to our economy.

While walleye have been rare in Long Point Bay since the 1960's, recent large year classes of this species in the Western Basin have led to a lake-wide expansion of the population. Subsequently, since 1983, catches of walleye by both sport and commercial fishermen have been increasing in Long Point Bay. A continuation in this trend may eventually lead to the development of another important fishery in the bay.

Throughout this document we have used common names for the various fish species mentioned; scientific names for these species are provided in Table 2.2-1.

Table 2.2-1. Common and scientific names of fishes caught in this study.

| | |
|---|---|
| Lamprey | *Petromyzon* or *Ichthyomyzon* sp. |
| Lake sturgeon | *Acipenser fulvescens* |
| Longnose gar | *Lepisosteus osseus* |
| Bowfin | *Amia calva* |
| Alewife | *Alosa pseudoharengus* |
| Gizzard shad | *Dorosoma cepedianum* |
| Coho salmon | *Oncorhynchus kisutch* |
| Chinook salmon | *O. tshawytscha* |
| Pink salmon | *O. gorbuscha* |
| Rainbow trout | *Salmo gairdneri* |
| Brown trout | *S. trutta* |
| Lake trout | *Salvelinus namaycush* |
| Brook trout | *S. fontinalis* |
| Lake whitefish | *Coregonas clupeaformis* |
| Rainbow smelt | *Osmerus mordax* |
| Mooneye | *Hiodon tergisus* |
| Northern pike | *Esox lucius* |
| Muskellunge | *E. masquinongy* |
| Goldfish | *Carassius auratus* |
| Lake chub | *Couesius plumbeus* |
| Carp | *Cyprinus carpio* |
| Golden shiner | *Notemigonus crysoleucas* |
| Emerald shiner | *Notropis atherinoides* |
| Common shiner | *N. cornutus* |
| Spottail shiner | *N. hudsonius* |
| Sand shiner | *N. stramineus* |
| Mimic shiner | *N. volucellus* |
| Bluntnose minnow | *Pimephales notatus* |
| Fathead minnow | *P. promelas* |
| Blacknose dace | *Rhinichthys atratulus* |
| Longnose dace | *R. cataractae* |
| Quillback | *Carpiodes cyprinus* |
| White sucker | *Catostomus commersoni* |
| Redhorse sucker | *Moxostoma* sp.[1] |
| Yellow bullhead | *Ictalurus natalis* |
| Brown bullhead | *I. nebulosus*[2] |
| Channel catfish | *I. punctatus* |
| Stonecat | *Noturus flavus* |
| Madtom | *Noturus* sp. |
| American eel | *Anguilla rostrata* |
| Banded killifish | *Fundulus diaphanus* |
| Burbot | *Lota lota* |
| Brook silverside | *Labidesthes sicculus* |
| Brook stickleback | *Culaea inconstans* |
| Trout perch | *Percopsis omiscomaycus* |
| White bass | *Morone chrysops* |
| White perch | *M. americana* |
| Rock bass | *Ambloplites rupestris* |
| Pumpkinseed | *Lepomis gibbosus*[3] |
| Bluegill | *L. macrochirus* |
| Smallmouth bass | *Micropterus dolomieui* |
| Largemouth bass | *M. salmoides* |
| White crappie | *Pomoxis annularis* |
| Black crappie | *P. nigromaculatus* |
| Yellow perch | *Perca flavescens* |
| Sauger | *Stizostedion canadense* |
| Walleye | *S. vitreum* |
| Iowa darter | *Etheostoma exile* |
| Johnny darter | *E. nigrum* |
| Logperch | *Percina caprodes* |
| Channel darter | *P. copelandi* |
| Freshwater drum (Sheepshead) | *Aplodinotus grunniens* |
| Sculpin | *Cottus* sp. |

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[1] Presumably mostly shorthead redhorse *M. macrolepidotum*.

[2] May include black bullhead *I. melas*.

[3] Identifications of green and redear sunfish in 1971 and 1972 are doubtful.

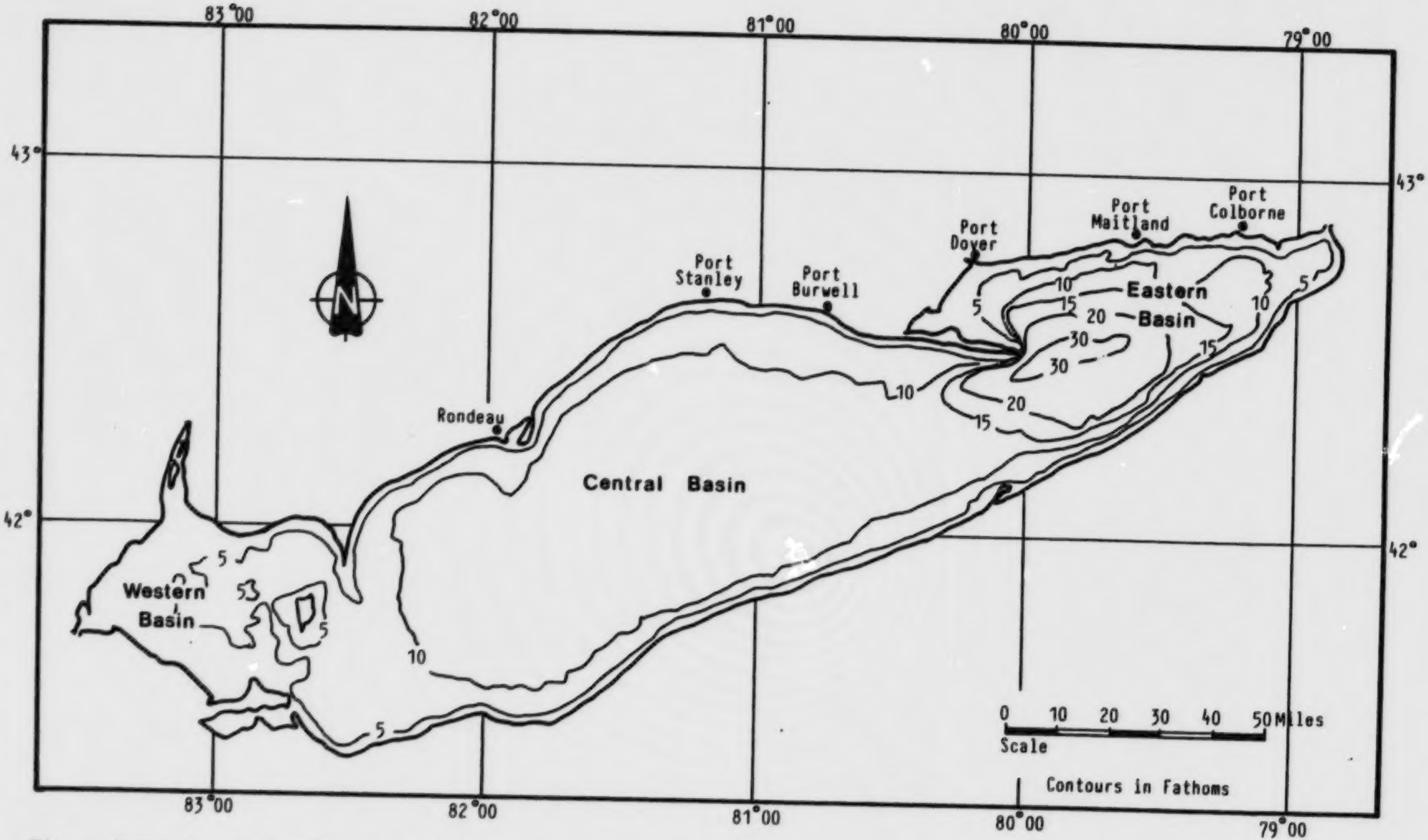
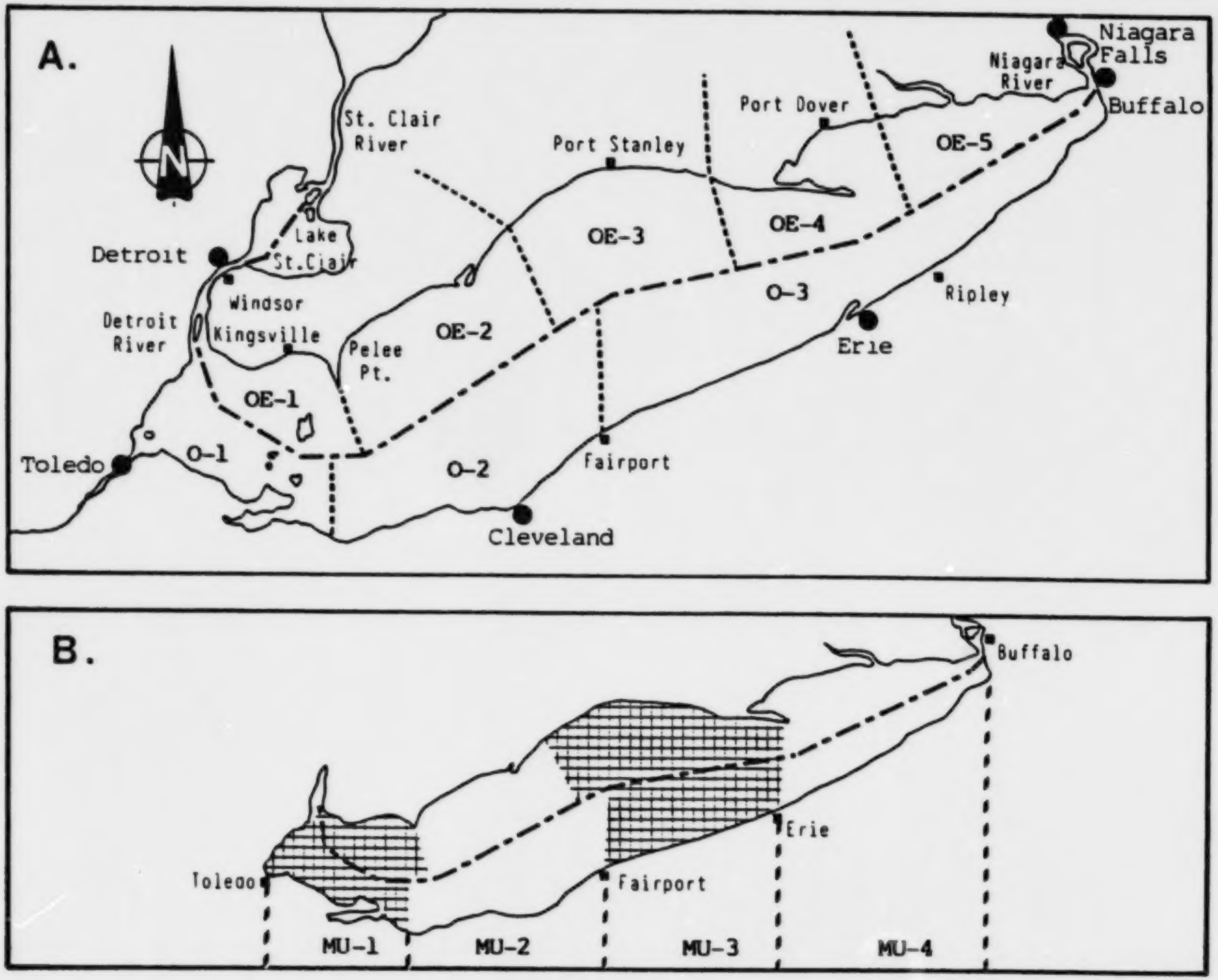

83°00
82°00
81°00
80°00
79°00
43°
42°
N
Port Colborne
Port Maitland
Port Dover
Port Burwell
Port Stanley
Rondeau
Eastern Basin
Central Basin
Western Basin
5
10
15
20
30
0 10 20 30 40 50 Miles
Scale
Contours in Fathoms

Figure 2.1.1-1. Bathymetry of Lake Erie.



A.
N
St. Clair River
Lake St.Clair
Detroit
Windsor
Detroit River
Kingsville
Pelee Pt.
Toledo
OE-1
O-1
OE-2
O-2
OE-3
OE-4
O-3
OE-5
Port Stanley
Port Dover
Niagara River
Niagara Falls
Buffalo
Ripley
Erie
Fairport
Cleveland
B.
Buffalo
Erie
Fairport
Toledo
MU-1
MU-2
MU-3
MU-4

Figure 2.1.1-2. (A) Statistical Districts for Lake Erie.
(B) Lake Erie Management Units.

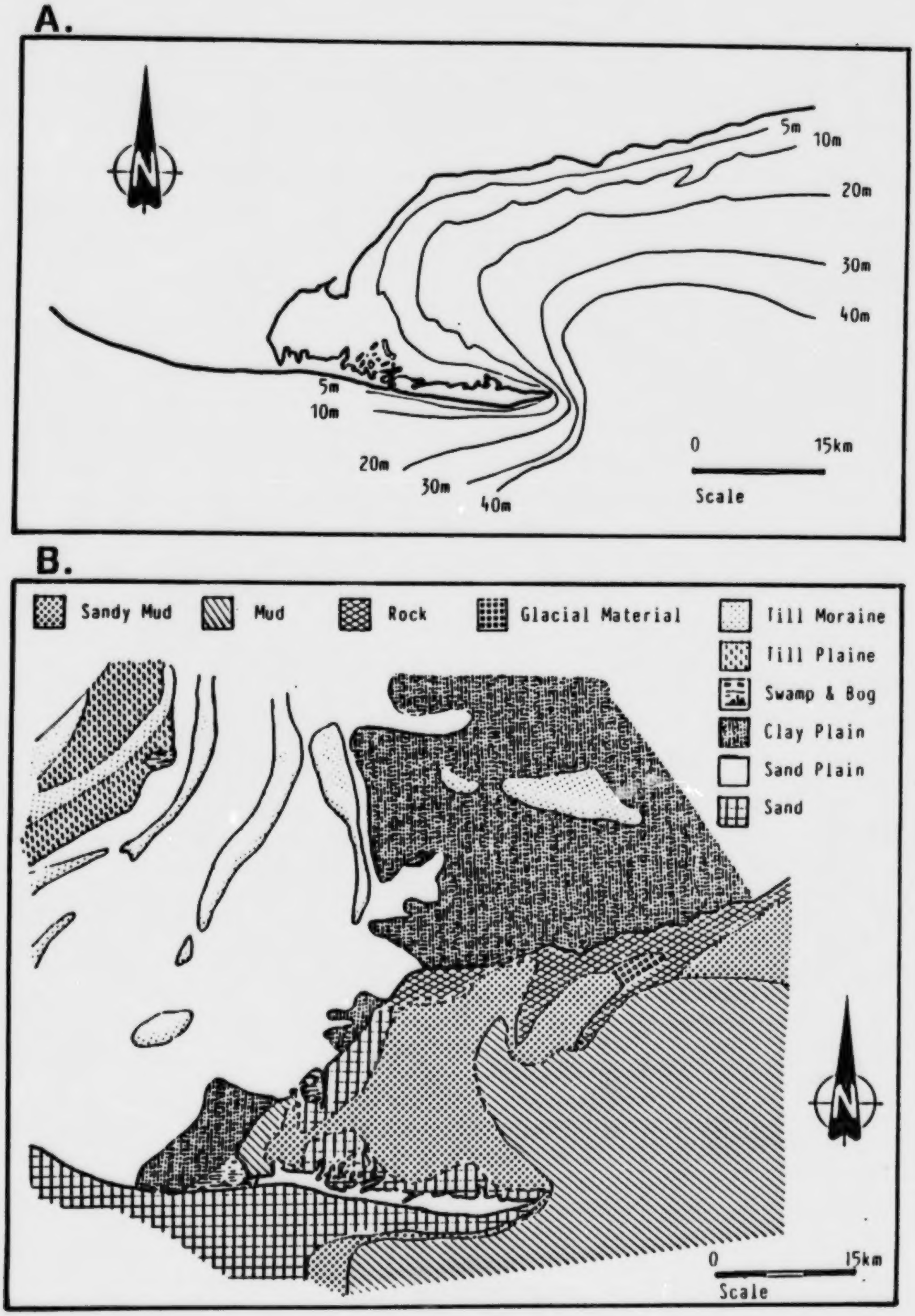

A.
N
5m
10m
20m
30m
40m
5m
10m
20m
30m
40m
0
15km
Scale
B.
Sandy Mud
Mud
Rock
Glacial Material
Till Moraine
Till Plaine
Swamp & Bog
Clay Plain
Sand Plain
Sand
N
0
15km
Scale

Figure 2.1.2-1. (A) Bathymetry of Long Point Bay

(B) Composition of bottom deposits in Long Point Bay and surficial deposits of surrounding region.

NOTE: Both figures adapted from Heathcote (1980).

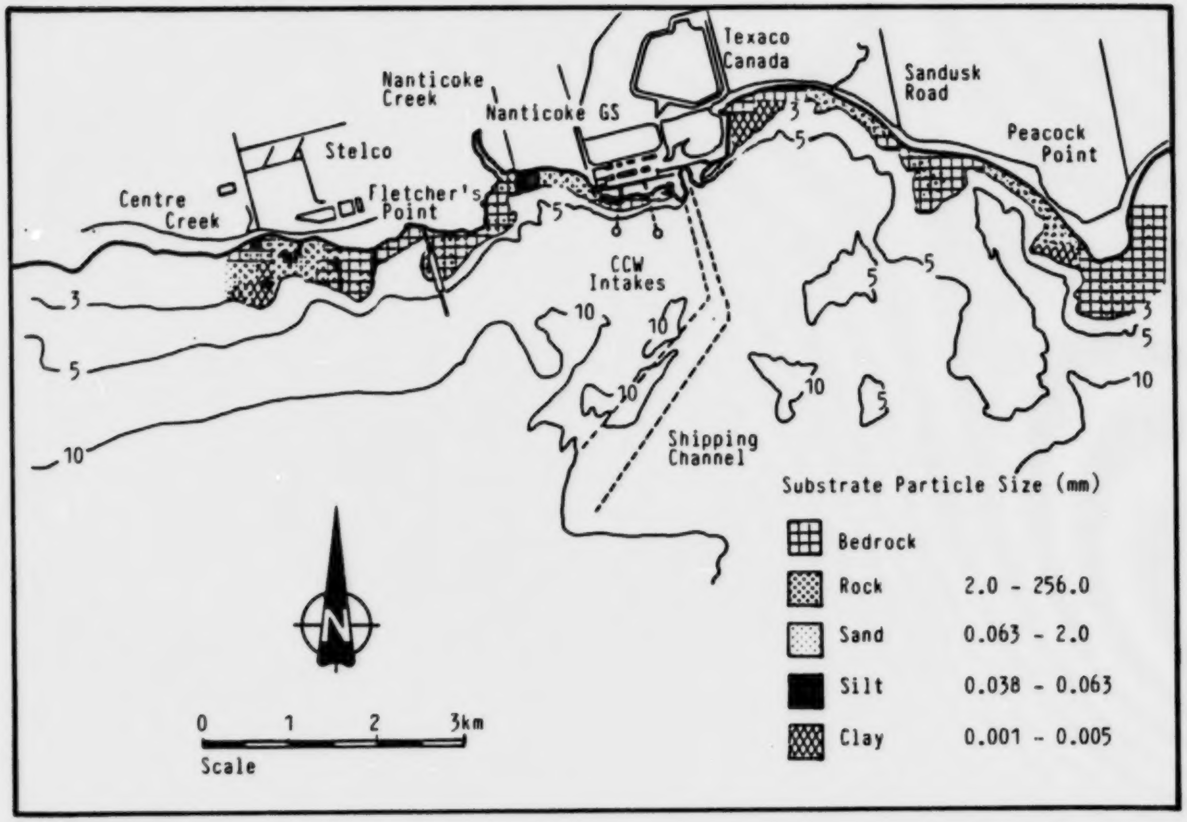

Nanticoke Creek
Nanticoke GS
Texaco Canada
Sandusk Road
Peacock Point
Stelco
Centre Creek
Fletcher's Point
CCW Intakes
Shipping Channel
3
5
10
Substrate Particle Size (mm)
Bedrock
Rock 2.0 - 256.0
Sand 0.063 - 2.0
Silt 0.038 - 0.063
Clay 0.001 - 0.005
0 1 2 3km
Scale
N

Figure 2.1.3-1. Nearshore substrate and bathymetry of the Nanticoke study area, Long Point Bay, Lake Erie (adapted from Kirby and Dunford 1981).

# 3.0 FISH ABUNDANCE AND DISTRIBUTION

## 3.1 LARVAL FISH

### Introduction

The abundance of a generation of fish is determined largely by their success during the first year of life (Koonce et al. 1977). Knowledge of larval fish distribution and abundance over time and space, therefore, is invaluable in assessing the effects of environmental stresses. In this regard, a series of field studies on larval fish were initiated in the waters fronting the Nanticoke Industrial Complex. The intent of all larval studies was to develop yearly, seasonal, and spatial indices of larval abundance specific to the study objectives.

Four surveys of larval fish have been operated at Nanticoke since 1971: (1) lake study or regular monitoring, 1971-1983; (2) NTGS entrainment study, 1974-1978; (3) Stelco dock study, 1976 and (4) Centre Creek study, 1978-1983. In regular monitoring, the abundance and distribution of larval fish 0.8 to 1.6 km offshore of Nanticoke was examined. The Centre Creek study was an investigation of larval fish distribution at selected distances from shore near the outfall of Stelco's effluent into Lake Erie. This report describes the lake (1972-1983) and Centre Creek (1980-1983) larval fish surveys at Nanticoke. Results of The NTGS entrainment and Stelco dock studies have been described previously (Chamberlain 1979). All larval data collected prior to 1979 have been summarized by Van Eeckhaute et al. (1981) and Hamley et al. (1981, 1983). Field survey activities were curtailed in 1979; consequently, no data are available for this year.

Data from 1971 (reported in Van Eeckhaute _et al_. 1981) are also excluded because these were not available on computer files.

## Methods

### A. Regular Monitoring

Regular monitoring of larval fish at Nanticoke experienced several sampling design and procedural changes from 1971 to 1978. These changes were documented in annual (Kelso 1972, 1973a; Teleki 1973, 1976; Teleki _et al_. 1977) and summary reports (Hamley _et al_. 1981, Van Eeckhaute _et al_. 1981). After 1978, sampling design was much simplified and the methods better standardized. Regular monitoring from 1980-1983 was done entirely at three locations, and only at mid-water depths during daylight hours (0700 to 1900 h). Details of design and methodology from 1972-1978 will not be described here except where they differ from the 1980-1983 period.

Regular monitoring locations in 1980 - 1983 (Figure 3.1-1) were as follows:

| | Latitude<br>(deg. min. sec.) | Longitude |
|---|---|---|
| 1) WEST STELCO | 42 46 36 | 80 05 36 |
| 2) HYDRO INTAKES | 42 47 06 | 80 03 29 |
| 3) NTGS PLUME | 42 47 36 | 80 02 17 |

Before 1980, larval fish sampling locations were designated by grid systems designed by Kelso (1973a) and Teleki (1973) (Figure 3.1-1). In Kelso's system, vertical and horizontal grid lines were produced at

8.1-km (5-mile) intervals. Vertically, grid squares were further subdivided into 1.6-km (1-mile) intervals; these were labeled with alpha characters A to H. Sample sites in 1971 and 1972 were selected along each of these vertical lines at distances of 60-120 m, 300 m, and 700 m from shore.

Teleki's grid system, adopted in 1973, consisted of 2.8-km squares spaced 2 minutes longitude by 1.5 minutes latitude. Grid squares were identified by a 4-digit number: the first two digits described the east-west division, the last two digits described the north-south division. Several sites were sampled within each grid square in 1973 to 1978, but the same sites were not sampled consistently each year.

Locations first established by Kelso (1971-1972) were later translated to Teleki's grid system (Van Eeckhaute _et_ _al_. 1981). Several locations were sampled within each Teleki - grid square before 1978, but the number of samples collected was small and the interval between samplings inconsistent. Following the recommendations of Lipsit (1977), the number of sampling locations in 1978 and later was reduced to three sites (West Stelco, Hydro Intakes, NTGS Plume). To facilitate data comparisons across all years, locations sampled before 1978 were pooled by grid No. (0510, 0610, 0710, 0810, 0910) and, in addition, the adjacent grids 0510 and 0610, and 0810 and 0910 were pooled. In this report all tow sites within the pooled grids 0910 and 0810 were called West Stelco, tow sites within grid 0710 were called Hydro Intakes, and those within pooled grids 0610 and 0510 were called NTGS Plume (Figure 3.1-1).

Larval tows were conducted at bi-weekly intervals from May to July in 1980 to 1983, but as late as August before 1978. In general, sampling was discontinued after July because zooplankton became too dense to enable efficient sorting of larval fish. Hamley (pers. comm.) recommended that the regular monitoring program be modified to achieve greater sample size and eliminate inconsistencies in the pre-1980 data. Thus, in the 1980-1983 regular monitoring program, larval tows were made only at mid-water depths (middle third of water column) during daylight hours (0700 - 1900 h) with a 1-m diameter plankton net (metre net) made of 526-µm mesh. Two nets were towed from the stern of the David-M for 5 minutes, 9 successive times; 18 replicate tows were generated at each location per sampling period.

Before 1980, the design factors - tow depth, diel period, net size, and mesh size - were confounded with year. From 1973 to 1978 larval tows were made at three depths with two sizes of plankton nets: 0.5-m nets for surface tows and metre nets for mid-water and bottom tows. From 1974 to 1977 sampling occurred at four diel periods, dawn (0501-0700 h), day (0701-1900 h), dusk (1901-2100 h), and night (2101-0459 h), but was reduced to just day and night tows in 1978. The mesh size of plankton nets was changed from 782 µm to 526 µm in 1976 because of concern that smaller larval fish were passing through the 782-µm mesh (Van Eeckhaute et al. 1981). In 1978, tows were made in triplicate, and without replication before 1978.

In our analyses of the full data series (1972-1983) only day and night tows were selected, and these were pooled. We also selected and pooled tows made at mid-water and bottom depths. The exclusion of all surface tows, resulted also in the exclusion of all tows with 0.5-m nets (all surface tows were sampled with 0.5-m nets). Combining day and night tows was a reasonable treatment of the data; preliminary anaylsis of 1978 data (Hamley et al. 1981) showed that smelt catches at mid water and bottom depths were similar in the day and in the night; whereas, surface catches were significantly smaller than mid-water and bottom catches during both diel periods. The above selection of data was advantageous in several respects: 1) net size was standardized over all years, 2) the number of design factors was reduced, which simplified the statistical analysis and interpretation of the results, and 3) sample size was increased and the balance among design factors improved.

Larval tows at mid-water and deeper depths were made from a 12.8-m (42') diesel powered trapnet boat (David-M). Constant tow speed of approximately 1 m/sec was maintained by controlling engine revolution rate at 800 rpm. Actual rate of water flow through plankton nets was not determined until 1976 when a General Oceanics digital flowmeter was attached to the mouth of some nets.

Water temperature, wind speed, and wind direction were recorded at each location. At the completion of each 5-minute tow, the nets were pulled aboard and rinsed several times. The collection bottle at the end of each plankton net was removed and its contents washed into a labeled jar containing 36% formaldehyde. If necessary, filtered water was added to samples to dilute them to 10% formalin.

In the laboratory, samples were emptied into trays and examined carefully. Larval fish were removed and placed in labeled vials containing 10% formalin. Identification and enumeration of larval fish were performed by NFS staff, except for 1980 and 1981 samples, which were examined by Dr. D. Faber (National Museum of Natural Sciences, Ottawa, Ontario). Larval fish were identified into the following five categories: rainbow smelt, yellow perch, clupeidae, cyprinidae, and others.

Subsamples of three or so larvae (per species) from each tow were measured for length and weight in some years. Lengths were measured to the nearest 0.1 mm with an ocular micrometer. Weights (nearest 0.1 mg) of larvae, after blotting excess moisture, were measured with a Sartorius analytic balance.

### B. Centre Creek Larval Fish Studies

Concern over the forthcoming discharge of Stelco's effluent via Centre Creek prompted additional larval fish monitoring beginning in 1978. The objective of this survey was to examine the relative abundance and taxonomic composition of larval fish at 50, 100, and 500 m from shore in the immediate vicinity of Stelco's discharge effluent. The pre-1983 larval collections presented in this report represent conditions while Stelco was operating below design capacity and provide a reference base to which data from future surveys may be compared. Larval data from 1978 were excluded because of methodological inconsistencies with the later years (1980-1983); methods during the two periods (1978 versus 1980-1983) differed in the numbers of replicate tows (3 versus 6), tow duration, (3 versus 5 minutes), and tow depth (surface, mid-water, bottom at some locations versus mid-water at all locations). Sampling (aboard the 8.2-m Eco) occurred bi-weekly from May to August. Two 0.5-m plankton nets with 526-μm mesh were towed for 5 minutes parallel to shore. Three mid-water tows were made at each distance from shore for a total of six replicates. A flowmeter was attached to the centre of the net to estimate volume of water filtered. Constant tow speeds of approximately 1 m/sec were maintained by controlling engine revolution rate, which varied from 800 to 1200 rpm. Environmental variables were recorded and larval fish samples processed in the same manner as in regular monitoring.

## C. Statistical Analyses

Larval data from the regular monitoring program (1972-1983) were analysed separately from Centre Creek data (1980-1983). However, because the same statistical procedures were applied to both data sets, a single description of the statistical treatments will suffice with exceptions noted.

Preliminary statistical analyses of larval fish data from the earlier years (1972-1978) were performed by Howley (1980a). A review of his work by a competent bio-statistician (Hines 1982), however, generated some concerns about the kinds of statistical treatments that were applied. Based on the recommendations of Hines (1982) a new approach to the analysis of larval fish data was adopted. Raw (counts) and standardized (by sampling effort for smelt data only) catches of the two most common larval species (smelt and perch) were analysed for effects of year, season, and location. Parametric analyses of variance (ANOVA) were judged inappropriate because larval fish were absent from a substantial portion of the tows (40% of 1,960 larval tows were void of smelt, 84% were void of yellow perch, and 33% contained no larvae at all). This high proportion of zero-catches skewed the distribution and rendered the data non-normal with unequal variance. To alleviate the requirement of normality and constant variance, a categorical data analysis was applied.

Logit analysis (Kleinbaum and Kupper 1978, Grizzle et al. 1969) was chosen over a possible alternative, log-linear analysis, (Bishop et al. 1975) because the former analysis treats catch as a dependant variable and the others (year, season, location) as independent variables similar to an ANOVA; whereas, all variables are treated as independents in log-linear analysis. In general, the treatment of catch as a dependent variable makes the results of logit analysis more interpretable than with log-linear analysis.

The counts of larvae captured in each tow were divided into two categories: (1) present (catch > 0) versus absent (catch = 0) tested in all species categories, or (2) catches of two smelt larvae or less (catch $\leq$ 2) versus catches of more than two smelt larvae (catch > 2). Although logit analysis can handle more than two response categories, only dichotomized groupings were tested to simplify interpretation of the results, and to reduce the number of cells in which larvae were absent (total number of cells = No. response categores x No. years x No. seasons x No. locations).

Various combinations and groupings of the design factors - year, location, and season (bi-weekly periods from early May to late August) - were analysed to minimize the incidence 0-catch among treatment cells, and to avoid empty cells (cases when no larval tows were attempted), which might render the analysis unreliable. In general, levels within the main effects were condensed or omitted in the following manner:

1) years were grouped into three periods coinciding with the phases of industrial development: preoperational (1972-1973), commissioning (1974-1978), and operational (1980-1983),
2) the West Stelco and Hydro Intakes sampling locations were combined, to collectively represent a reference area west of the thermally heated NTGS Plume "test" location, and
3) bi-weekly periods, which had an insufficient number of tows or low catches were omitted from analysis (all August samples and in some analyses July and early May samples).

For 1-m net tows, logit analyses were performed with and without the inclusion of 1973 data.

Several analyses were run using the data most suited to achieving the desired statistical model. We attempted to ensure that the total number of tows (No. observations) was sufficient in each analysis (Johnson and Koch 1971). Apparently, no widely accepted criterion exists for the number of observations required to validate logit analysis. The criterion followed in the present analysis was that recommended by Stedl (1981), where the number of observations equalled or exceeded the number of treatment cells times 15. The version of logit analysis used was that contained in the Funcat procedure of SAS (SAS Inst. Inc.). A full model (tests of main effects and their interactions) was fitted. A recommended procedure is to fit simpler models by a stepwise elimination of interaction terms if they are found non-significant in a higher order model (Kleinbaum and Kupper 1978). However, because the present analysis involved only three factors (year, season, location) and second order interactions were in general highly significant, a graphical examination of the significant effects in the full model was judged to be a more valuable means of gaining insight into the data than to performing further logit analysis with non-significant terms removed. The significant ($P <$ .01) effects were examined by plotting the observed catch response (for example: percent of tows catching one or more larvae) for the various combinations of factors in that effect.

## Results

No larval fish species was caught consistently in every tow (Table 3.1-1-2). In fact, smelt, by far the most common species (91% of the total catch) were present in only 60% of all 1-m net tows (No. tows = 1,958). Perch were much less abundant (present in fewer than 20% of all tows); their numbers relative to other species were highest near shore (23% of total catch in 0.5-m nets towed 50 to 500 m offshore versus 4% of total catch in 1-m nets towed 800 to 1600 m offshore). Similarly, cyprinids were more abundant (11% of total catch) in the shallow waters fronting Centre Creek (1-5 m) sampled with 0.5-m nets than in the deeper waters (7-10 m) sampled with 1-m nets (2% of total catch). Clupeids were caught in fewer than 10% of all tows. Catch statistics summarized by year, location, and biweekly period are given in Tables 3.1-3 to -13 (regular monitoring) and 3.1-14 to -17 (Centre Creek).

Replication of larval fish tows (ie. tows made over the same area, in the same direction within a short time of each other) did not commence until 1978, but only in triplicate in that year. From 1980 to 1983, tows were replicated 18 times. Catches in these years, therefore, provide the best insight into the extent of variability among replicates. Replicate tows during periods of relatively high and low larval abundance were compared; the following examples were chosen:

| Year | Relative Abundance | No. of smelt caught in replicate 1-m net tows at Hydro Intakes in late June | No. of perch caught in replicate 1-m net at NGS Plume in late May |
|---|---|---|---|
| 1981 | High | 7,0,141,114,130,185,148, 112 ,265,148,112,136, 177,220,117,204,107, 191,77<br>(Mean=143.9,Var=3388.3) | 0,9,4,5,1,5,9,4,4,7, 24,7,12,11,8,4,9,4<br>(Mean=7.1,Var=28.3) |
| 1983 | Low | 4,9,5,3,5,3,7,2,4,9,9, 6,10,10,9,5,4,6<br>(Mean=6.1,Var=6.9) | 0,0,0,0,0,0,0,0,0,0, 0,0,0,0,0,0,0,2<br>(Mean=0.1,Var=0.2) |

Clearly, in times of both relatively high and low larval abundance the variation in catch among replicate tows was high, with sample variances usually much larger than their means.

### (i) Location

The effect of location on larval catches in 1-m nets was insignificant (P > .01) in all analyses (Figures 3.1-2 and -4) except one; catches of three or more smelt were significantly (P < 0.001) higher at West Stelco than at Hydro Intakes and NTGS Plume (Figure 3.1-3). However, when West Stelco and Hydro Intakes were combined as one location and compared to NTGS plume, spatial effects were not statistically apparent (Figure 3.1-4). In general, perch larvae were caught in more tows in the thermally heated waters near the NTGS Plume than at the western locations. Larval perch abundance appeared to shift westward with progression of season. Perch densities in early June were highest at the NTGS plume, but two weeks later (late June) their densities were highest at West Stelco. This shift in larval distribution resulted in a highly significant (P = 0.0001) interaction of location with season (Figures 3.1-3).

In Centre Creek's outfall (0.5-m net tows), the number of tows which caught at least one smelt larvae was significantly (P < 0.05) higher at 100 and 500 m offshore than at 50 m off shore, but no statistical differences were found among the three distances from shore for the No. of tows catching 3 or more smelt (Figure 3.1-5). Perch larvae generally were caught in more tows near shore than off shore, but not significantly so. Catches of larval clupeids were very low (mean No. larvae per tow ranged from 0 to 0.9), and tended to increase with distance from shore (Tables 3.1-14 to -17). For cyprinids, larval density varied inversely with distance from shore; mean No. of larvae per tow was 0.54 (50 m), 0.47 (100 m), and 0.17 (500 m), respectively.

### (ii) Season

Rainbow smelt and yellow perch larvae appeared in the first larval tows of the sampling period, usually early May (Figures 3.1-7 and -8). Density of smelt (in 1-m nets averaged over all years) was highest in June when larvae averaged 8.5 mm in total length (TL) (Figure 3.1-9). Their densities generally dropped sharply by July when larvae had more than doubled in size (mean TL = 17.6 mm). Seasonal differences in the number of tows catching smelt were highly significant (P < 0.0001) (Figures 3.1-2, -3, and -6). The number of tows catching larval yellow perch also differed significantly among seasons. Peak densities of perch larvae, however, occurred at an earlier time off shore (early May) than near shore (June) (compare Figures 3.1-7 and

-8). Variations in catches of larval smelt and perch due to interactions of season with year or season with period were highly significant ($P < 0.0001$).

In the offshore waters (1-m nets), clupeids and cyprinids typically were first captured in June and their densities did not peak until August (Figure 3.1-7); whereas, in the nearshore waters sampled with 0.5-m nets cyprinids were first caught in May, and highest catch densities were in June (Figure 3.1-8).

### (iii) Year

The most apparent observation in comparing relative densities of larval fish across years was the large variations - more than 10 fold - with no obvious trends (Figures 3.1-10 and -11). Also conspicuous was the higher percentage of tows catching smelt after than before 1976. Statistically, the year-to-year variations in the number of tows catching larval smelt and perch were highly significant ($P < 0.001$) (Figures 3.1-4, -5, and -10). However, when years were grouped into the major phases of industrial development, effects due to period, in general, were insignificant ($P > 0.05$) except that more tows caught three or more smelt in the operational period (1980-1983).

## Discussion

Reliable indices of larval fish abundance were difficult to develop due to inconsistencies in sampling, naturally low and highly variable larval densities, and inefficiencies in our sampling gear. These factors were not unique to our studies, and have troubled most studies of larval fish (Bowles *et al*. 1978, Marcy and Dahlberg 1980).

Inconsistencies in larval sampling at Nanticoke before 1980 (eg. changes in sampling time, location, level of replication, tow depth and mesh size) were particularly troublesome. We did not attempt to adjust the catch data to compensate for possible biases caused by the irregular selection and application of sampling gear, as the effects were too confounded to isolate.

In logit analysis, the classification of catch into two categories (eg. catch = 0 versus > 0) resulted in some loss of information, which rendered statistical testing less sensitive than could have been achieved through an analysis of variance, had the catch data been normally distributed. Logit analysis, however, did permit a valid statistical examination of the effects of year, season, and location on catches of rainbow smelt and yellow perch larvae, despite a high proportion of zero catches and unequal sample sizes.

### (i) Location

Although average densities (No./1000 $m^3$) of larval smelt (111.0), yellow perch (3.8), clupeids (1.2) and cyprinids (1.5) at Nanticoke since 1971 (No. tows = 1,960) were low, they fell within the ranges observed in western Lake Erie (Cole and MacMillan 1984), in other Great Lakes (O'Gorman 1983, 1984, Tin and Jude 1983), and near other power stations (Mizera et al. 1981, Perrone et al. 1983). The relative abundance of larval smelt and perch sampled with 1-m nets was the same throughout Nanticoke. Some evidence of lower smelt densities was observed at the NTGS plume, but the effect was not consistent among the models tested.

Higher densities of larval fish, particularly smelt, in the vicinity of the thermal outfall were expected because spawning adults (smelt, white bass) aggregated in this area (see Section 4.2) and zooplankton (initial food of larval fish) tended to be more abundant in the plume than in areas to the west (Carter and Sardella 1985). Why larval fish were not plentiful in the thermal discharge relative to other areas (as was found for adult fish described in Section 3.2.1) may be because of water currents. Fish larvae, particularly newly-hatched ones, are weak swimmers. Their movements are determined largely by wind and lake generated currents (Bishai 1959). Heufelder _et_ _al_. (1982) postulated that the abundance of larval alewife in eastern Lake Michigan was reduced during wind-induced upwellings of cold hypolimnetic water due to mortality of larvae from cold-shock, or to movements of larvae (passive or active) and potential spawning adults. At Nanticoke, water currents averaging 2-18 cm/s were predominately along shore from west to east in response to prevailing westerly winds (Kohli and Farooqui 1980). Therefore, totally passive larvae, (the ones most vulnerable to our gear) likely were transported one to several kilometers in a day. Larval fish collections at Nanticoke occurred at only a few locations once every other week and lasted for only a few minutes at a time. Sampling at this intensity and frequency was probably insufficient for determination of true spatial differences in larval abundance, particularly if larvae were transported to and from the study area over relatively short periods.

A significant interaction of location with season in larval perch catches appeared to be due to a westward shift in larval abundance through May and June (Figure 3.1-3), and may be attributed to spatial differences in time of spawning, or to differential growth rates. Water temperatures were warmer near the Nanticoke thermal discharge (May average = 12°C) than in the areas sampled west of the plume (May average = 10°C). Although no yellow perch eggs were found anywhere in the Nanticoke area during our spawning surveys (Section 4.2), the few collections of larval perch suggests that at least some perch spawning occurred in or near the plume. If so, spawning may have begun earlier in the plume than in waters outside the area of thermal influence. The growth of larvae spawned in the plume, or even for those spawned outside but transported to the thermal discharge area, may have been accelerated by the warm plume temperatures. Larvae in these waters may have attained a size vulnerable to our gear earlier than did larvae elsewhere. However, our water temperature and larval growth data were inadequate to determine if such a relationship existed.

The differences in relative abundance of the major larval species (rainbow smelt and yellow perch, Figure 3.1-5) and of less common groups (clupeids and cyprinids) at 50, 100 and 500 m offshore of Centre Creek's outfall (Stelco's effluent) probably were not related to Stelco's effluent; rather, they were typical of age-specific habitat requirements (such as water depth) for each species. Our findings of increased numbers of smelt and clupeids and decreased numbers of cyprinids and yellow perch with greater distance from shore (Tables 3.2-14 to -17) corroborate those of Cooper et al. (1981) and Mizera et al. (1981).

### (ii) Season

The appearance of smelt and perch larvae in early May (Figure 3.1-7) coincided with their expected time of hatch. Spawning by these species at Nanticoke begins about mid-April when water temperatures approach 10°C, and is followed by a two to three week incubation to hatch. Statistically significant differences in densities of larval smelt and perch among seasons were expected. Other larval fish studies using plankton nets have shown seasonal trends in larval density similar to ours (O'Gorman 1983, Perrone et al. 1983, Tin and Jude 1983). We have shown that smelt and perch larval densities increase progressively from May to June (Figure 3.1-7). Maximum densities in June occurred when larvae were <10 mm (Figure 3.1-7); thereafter, growth accelerated rapidly while larval catches fell sharply, presumably because larger (>10 mm) larvae were better able to avoid our slow-moving nets. Newly hatched larval perch and smelt are approximately 5-6 mm (Auer 1982) and grow 0.3 - 0.5 mm/day (Mansueti 1964, Tin and Jude 1983). The average length of captured larvae was approximately 7 mm in May and 8 mm in June. This implies that larvae primarily one week or so old were the most vulnerable to our gear. Perrone et al. (1983) also identified net avoidance by larger yellow perch as the main reason why so few (<10%) larvae >7.5 mm were taken in 0.5-m plankton nets towed near two power stations in Lake Michigan. Tin and Jude (1983) believe smelt larvae began avoiding plankton nets in late June when larvae had grown to 20 mm. That only a few yellow perch >10 mm and rainbow smelt >15 mm were caught indicates that the larger ones were able to avoid capture or may have moved out of the sampling area. However, predation and environmentally induced mortality likely were factors depleting numbers of larvae through the summer. The occurrence of some small larvae in summer suggests that larvae originated from several areas where temperature regimes differed or the spawning period was extended.

A significant interaction of season with year (Figure 3.1-6) is best explained by variability in spawning time and relative growth rates from year to year. Interaction of season with period was also significant in catches of smelt larvae, possibly for the same reasons. Another explanation of why smelt larvae appeared to be more abundant in May during the operational period (1980-1983) than before (1972-1979) may be because of a gear change to smaller mesh plankton net in 1976 (Figures 3.1-2 and -3). O'Gorman (1984) demonstrated that the numbers of larval smelt and alewife captured in 0.5-m plankton nets varied inversely with mesh size, and that the average length of captured larvae varied directly with mesh size. Investigations in western Lake Erie suggest a similar relationship - that mesh sizes >363 µm failed to adequately sample newly-hatched larval perch, smelt, and clupeids (Cole and MacMillan 1984). In our studies, the mean size of larvae captured in June was larger before 1976 (smelt TL = 9.0 mm; perch TL = 8.6 mm) than after 1976 (smelt TL = 8.1 mm; perch TL = 7.1 mm) when the mesh size of sampling nets was reduced from 782 to 526 µm. The 526-µm mesh (1976-1983) likely captured more smaller larvae (5-7 mm), which were abundant in May and June, than did the 782-µm mesh (1971-1976).

### (iii) Year

The number of tows catching larval fish and number of larvae per 1000 $m^3$ of filtered lake water were higher during the operational years (1980-1983) than in the earlier years. The apparent increase in larval smelt abundance after 1976 (Figure 3.1-12) is suspect, however, and may be due in part to sampling bias. The aforementioned change to smaller mesh plankton net (526 µm) in 1976 probably resulted in a greater retention of small smelt larvae.

Index fishing with small mesh trawls for young-of-the-year (YOY) and yearling fish in the fall was initiated at Nanticoke in 1980 to estimate year class strengths of important species (primarily yellow perch and smelt). However, technical difficulties relating to poor bottom conditions precluded the development of reliable indices for juvenile age groups, and thus the possibility of comparing such measures with our indices of larval fish abundance. As an alternative, we examined the relationship between larval fish indices at Nanticoke and trawl indices of YOY and yearling abundance from other parts of Lake Erie (trawl indices were provided by U.S. Fish and Wildlife Service, Sandusky, Ohio, and the Lake Erie Fisheries Research Station, Wheatley, Ontario). There appeared to be no linear relationship ($P>0.05$) between our larval indices of abundance and subsequent year class strength. This was not unexpected and can be attributed to sampling bias described previously for larval fish and wide year-to-year variations in mortality rates, emigration and immigration during the first few months after eggs hatch.

### (iv) Summary

Differences in larval abundance were highly significant among years and slightly so among locations, but the relationship of these differences to industrial activity are unclear. Low densities of highly mobile (passive or active) larval populations, distributed in patches over relatively large areas, resulted in a high percentage of zero catches. Because the data were not normally distributed, we were forced to use analytical procedures that were less discriminating than the preferred parametric analyses (ie. analysis of variance). Naturally high variability in larval abundance meant that several years of data collection were needed to establish a reliable data base in which to compare future observations. However, larval sampling methods during the reference (baseline) period were inconsistent. This, combined with a generally poor understanding of how sampling methods (tow speed, tow depth, time of sampling, mesh size), larval fish behaviour (diel migrations, net avoidance, age or size specific habitat requirements), and environmental conditions (temperature, wind current, turbidity, bottom structure) interact to affect catch, greatly complicated interpretations of the results.

Table 3.1-1. Frequency distributions of the numbers of larval fish caught in 1-m plankton nets during regular monitoring at Nanticoke (West Stelco, Hydro Intakes, NGS Plume). Summary statistics are given below each distribution. Data are from early May to late August, 1972 - 1983 (ε% = cummulative percent).

| Number caught in a tow | Smelt | | Perch | | Clupeid | | Cyprinid | | Other | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Freq | ε% | Freq | ε% | Freq | ε% | Freq | ε% | Freq | ε% |
| 0 | 785 | 40.1 | 1636 | 83.5 | 1822 | 93.0 | 1871 | 95.5 | 1749 | 89.2 |
| 1 | 182 | 49.3 | 173 | 92.3 | 72 | 96.6 | 45 | 97.8 | 122 | 95.5 |
| 2 | 122 | 55.6 | 52 | 94.9 | 25 | 97.9 | 9 | 98.2 | 43 | 97.7 |
| 3 | 59 | 58.6 | 28 | 96.4 | 12 | 98.5 | 9 | 98.7 | 13 | 98.3 |
| 4 | 68 | 62.0 | 20 | 97.4 | 6 | 98.8 | 9 | 99.1 | 6 | 98.7 |
| 5 | 56 | 64.9 | 11 | 98.0 | 4 | 99.0 | 4 | 99.3 | 4 | 98.8 |
| 6 | 41 | 67.0 | 2 | 98.1 | 5 | 99.3 | 1 | 99.4 | 4 | 99.0 |
| 7 | 58 | 69.9 | 7 | 98.4 | 1 | 99.3 | 1 | 99.4 | 5 | 99.3 |
| 8 | 43 | 72.1 | 4 | 98.6 | 2 | 99.4 | | | 2 | 99.4 |
| 9 | 41 | 74.2 | 6 | 98.9 | 2 | 99.5 | 1 | 99.5 | 1 | 99.4 |
| 10 | 30 | 75.8 | 1 | 99.0 | 1 | 99.6 | | | 2 | 99.5 |
| 11-20 | 156 | 83.7 | 14 | 99.7 | 5 | 99.8 | 8 | 99.9 | 8 | 99.9 |
| 21-30 | 86 | 88.1 | 4 | 99.9 | | | | | 1 | 100.0 |
| 31-40 | 57 | 91.0 | 1 | 99.9 | 1 | 99.9 | | | | |
| 41-50 | 37 | 92.9 | 1 | 100.0 | 2 | 100.0 | 1 | 99.9 | | |
| 51-60 | 28 | 94.3 | | | | | | | | |
| 61-70 | 20 | 95.4 | | | | | | | | |
| 71-80 | 22 | 96.5 | | | | | | | | |
| 81-90 | 15 | 97.2 | | | | | | | | |
| 91-100 | 10 | 97.8 | | | | | | | | |
| 101-200 | 33 | 99.4 | | | | | | | | |
| 201-300 | 7 | 99.8 | | | | | 1 | 100.0 | | |
| >300 | 4 | 100.0 | | | | | | | | |
| No. Tows | 1958 | | 1958 | | 1958 | | 1958 | | 1958 | |
| Sum | 25826 | | 1015 | | 484 | | 576 | | 546 | |
| Mean | | 13.19 | | 0.52 | | 0.18 | | 1.29 | | 0.21 |
| Std Error | | 0.849 | | 0.051 | | 0.044 | | 0.132 | | 0.036 |

Table 3.1-2. Frequency distributions of the numbers of larval fish caught in ½-m plankton nets at selected distances (50 m, 100 m, and 500 m) offshore of Centre Creek's outfall. Summary statistics are given below each distribution. Data are from early May to late August, 1980-1983 (ε% = cummulative percent).

| Number caught in a tow | Smelt | | Perch | | Clupeid | | Cyprinid | | Other | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Freq | ε% | Freq | ε% | Freq | ε% | Freq | ε% | Freq | ε% |
| 0 | 228 | 55.7 | 309 | 75.6 | 393 | 96.1 | 343 | 83.9 | 380 | 92.9 |
| 1 | 60 | 70.4 | 49 | 87.5 | 8 | 98.0 | 28 | 90.7 | 24 | 98.8 |
| 2 | 37 | 79.5 | 15 | 91.2 | 3 | 98.8 | 15 | 94.4 | 4 | 99.8 |
| 3 | 19 | 84.1 | 6 | 92.7 | 4 | 99.8 | 9 | 96.6 | 1 | 100.0 |
| 4 | 14 | 87.5 | 5 | 93.9 | 1 | 100.0 | 5 | 97.8 | | |
| 5 | 11 | 90.2 | 6 | 95.4 | | | 3 | 98.5 | | |
| 6 | 4 | 91.2 | 3 | 96.1 | | | 3 | 99.3 | | |
| 7 | 2 | 91.7 | 2 | 96.6 | | | 1 | 99.5 | | |
| 8 | 6 | 93.2 | 3 | 97.3 | | | 1 | 99.8 | | |
| 9 | 5 | 94.4 | 0 | 97.3 | | | 1 | 100.0 | | |
| 10 | 6 | 95.8 | 3 | 98.0 | | | | | | |
| 11-20 | 8 | 97.8 | 8 | 100.0 | | | | | | |
| 21-30 | 5 | 99.0 | | | | | | | | |
| 31-40 | 2 | 99.5 | | | | | | | | |
| 41-50 | 2 | 100.0 | | | | | | | | |

| | Smelt | Perch | Clupeid | Cyprinid | Other |
|---|---|---|---|---|---|
| No. Tows | 409 | 409 | 409 | 409 | 409 |
| Sum | 880 | 330 | 30 | 162 | 35 |
| Mean | 2.15 | 0.81 | 0.07 | 0.40 | 0.09 |
| Std Error | 0.263 | 0.110 | 0.020 | 0.058 | 0.017 |

Table 3.1-3. Cummulative catch (Σ), mean catch per tow, and percentage of tows catching one or more (%>0) larval fish in 1-m plankton nets during regular monitoring at Nanticoke in 1972 (data includes day and night, and midwater and bottom tows).

| LARVAL SPECIES CATEGORY | STATISTIC | WEST STELCO | | | | | NGS PLUME | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BIWEEKLY PERIOD [1] | | | | | BIWEEKLY PERIOD [1] | | | | |
| | | 2 | 5 | 6 | 7 | 8 | 2 | 5 | 6 | 7 | 8 |
| | No. Tows | 3 | 10 | 0 | 0 | 6 | 3 | 6 | 8 | 2 | 6 |
| PERCH | Σ | 0 | 1 | | | 0 | 0 | 2 | 3 | 0 | 2 |
| | MEAN | 0.0 | 0.1 | | | 0.0 | 0.0 | 0.3 | 0.4 | 0.0 | 0.3 |
| | % > 0 | 0.0 | 10.0 | | | 0.0 | 0.0 | 33.3 | 37.5 | 0.0 | 33.3 |
| SMELT | Σ | 0 | 12 | | | 1 | 0 | 15 | 235 | 11 | 5 |
| | MEAN | 0.0 | 1.2 | | | 0.2 | 0.0 | 2.5 | 29.4 | 5.5 | 0.8 |
| | % > 0 | 0.0 | 40.0 | | | 16.7 | 0.0 | 50.0 | 100.0 | 100.0 | 33.3 |
| CLUPEID | Σ | 0 | 0 | | | 0 | 0 | 0 | 0 | 0 | 0 |
| | MEAN | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | % > 0 | 0.0 | 0.0 | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYPRINID | Σ | 0 | 0 | | | 23 | 0 | 0 | 0 | 8 | 111 |
| | MEAN | 0.0 | 0.0 | | | 3.8 | 0.0 | 0.0 | 0.0 | 4.0 | 18.5 |
| | % > 0 | 0.0 | 0.0 | | | 100.0 | 0.0 | 0.0 | 0.0 | 100.0 | 100.0 |
| OTHER | Σ | 0 | 1 | | | 0 | 0 | 0 | 1 | 0 | 0 |
| | MEAN | 0.0 | 0.1 | | | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| | % > 0 | 0.0 | 10.0 | | | 0.0 | 0.0 | 0.0 | 12.5 | 0.0 | 0.0 |
| ALL FISH | Σ | 0 | 14 | | | 24 | 0 | 17 | 239 | 19 | 118 |
| | MEAN | 0.0 | 1.4 | | | 4.0 | 0.0 | 2.8 | 29.9 | 9.5 | 19.7 |
| | % > 0 | 0.0 | 40.0 | | | 100.0 | 0.0 | 50.0 | 100.0 | 100.0 | 100.0 |

[1] Biweekly periods: 1 = early May 2 = late May 3 = early June 4 = late June
5 = early July 6 = late July 7 = early August 8 = late August

Table 3.1-4. Cummulative catch (Σ), mean catch per tow, and percentage of tows catching one or more (% > 0) larval fish in 1-m plankton nets during regular monitoring at Nanticoke in 1973 (data includes day and night, and midwater and bottom tows).

| LARVAL SPECIES CATEGORY | STATISTICS | WEST STELCO | | | HYDRO INTAKES | | | NGS PLUME | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | BIWEEKLY PERIOD[1] | | | BIWEEKLY PERIOD[1] | | | BIWEEKLY PERIOD[1] | | |
| | | 3 | 4 | 5 | 3 | 4 | 5 | 3 | 4 | 5 |
| | No. Tows | 23 | 9 | 11 | 9 | 6 | 16 | 2 | 1 | 0 |
| PERCH | Σ | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | |
| | MEAN | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.5 | 0.0 | |
| | % > 0 | 4.0 | 11.1 | 0.0 | 0.0 | 0.0 | 6.3 | 50.0 | 0.0 | |
| SMELT | Σ | 145 | 76 | 34 | 84 | 105 | 48 | 4 | 0 | |
| | MEAN | 6.3 | 8.4 | 3.1 | 9.3 | 17.5 | 3.0 | 2.0 | 0.0 | |
| | % > 0 | 64.0 | 100.0 | 36.4 | 100.0 | 100.0 | 50.0 | 100.0 | 0.0 | |
| CLUPEID | Σ | 5 | 1 | 11 | 0 | 44 | 10 | 0 | 14 | |
| | MEAN | 0.2 | 0.1 | 1.0 | 0.0 | 7.3 | 0.6 | 0.0 | 14.0 | |
| | % > 0 | 4.0 | 11.1 | 72.7 | 0.0 | 16.7 | 43.8 | 0.0 | 100.0 | |
| CYPRINID | Σ | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | |
| | MEAN | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | |
| | % > 0 | 0.0 | 0.0 | 18.2 | 0.0 | 0.0 | 6.3 | 0.0 | 0.0 | |
| OTHER | Σ | 73 | 8 | 2 | 9 | 36 | 55 | 0 | 1 | |
| | MEAN | 3.2 | 0.9 | 0.2 | 1.0 | 6.0 | 3.4 | 0.0 | 1.0 | |
| | % > 0 | 56.0 | 44.4 | 18.2 | 55.6 | 83.3 | 31.3 | 0.0 | 100.0 | |
| ALL FISH | Σ | 225 | 86 | 49 | 93 | 185 | 115 | 5 | 15 | |
| | MEAN | 9.8 | 9.6 | 4.5 | 10.3 | 30.8 | 7.2 | 2.5 | 15.0 | |
| | % > 0 | 84.0 | 100.0 | 72.7 | 100.0 | 100.0 | 87.5 | 100.0 | 100.0 | |

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[1] Biweekly periods: 1 = early May 2 = late May 3 = early June 4 = late June
5 = early July 6 = late July 7 = early August 8 = late August

Table 3.1-5. Cummulative catch (Σ), mean catch per tow, and percentage of tows catching one or more (%>0) larval fish in 1-m plankton nets during regular monitoring at Nanticoke in 1974 (data includes day and night, and midwater and bottom tows).

| LARVAL SPECIES CATEGORY | STATISTIC | WEST STELCO |  |  |  |  |  | HYDRO INTAKES |  |  |  |  |  | NGS PLUME |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | BIWEEKLY PERIOD ¹ |  |  |  |  |  | BIWEEKLY PERIOD ¹ |  |  |  |  |  | BIWEEKLY PERIOD ¹ |  |  |  |  |  |
|  |  | 2 | 3 | 4 | 5 | 6 | 7 | 2 | 3 | 4 | 5 | 6 | 7 | 2 | 3 | 4 | 5 | 6 | 7 |
|  | No. Tows | 24 | 21 | 32 | 14 | 17 | 22 | 8 | 8 | 10 | 4 | 10 | 4 | 0 | 4 | 4 | 2 | 6 | 4 |
| PERCH | Σ | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 |  | 0 | 0 | 0 | 0 | 0 |
|  | MEAN | 0.0 | 0.1 | <0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 |  | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
|  | % > 0 | 0.0 | 14.3 | 3.1 | 0.0 | 0.0 | 0.0 | 0.0 | 25.0 | 0.0 | 0.0 | 0.0 | 0.0 |  | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| SMELT | Σ | 0 | 49 | 92 | 53 | 3 | 6 | 0 | 13 | 4 | 10 | 41 | 0 |  | 4 | 3 | 0 | 7 | 1 |
|  | MEAN | 0.0 | 2.3 | 2.9 | 3.8 | 0.2 | 0.3 | 0.0 | 1.6 | 0.4 | 2.5 | 4.1 | 0.0 |  | 1.0 | 0.8 | 0.0 | 1.2 | 0.3 |
|  | % > 0 | 0.0 | 61.9 | 71.9 | 71.4 | 11.8 | 18.2 | 0.0 | 62.5 | 40.0 | 50.0 | 40.0 | 0.0 |  | 50.0 | 75.0 | 0.0 | 50.0 | 25.0 |
| CLUPEID | Σ | 0 | 0 | 1 | 2 | 23 | 52 | 0 | 0 | 0 | 0 | 12 | 9 |  | 0 | 0 | 0 | 19 | 4 |
|  | MEAN | 0.0 | 0.0 | <0.1 | 0.1 | 1.4 | 2.4 | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 2.3 |  | 0.0 | 0.0 | 0.0 | 3.2 | 1.0 |
|  | % > 0 | 0.0 | 0.0 | 3.1 | 14.3 | 35.3 | 72.7 | 0.0 | 0.0 | 0.0 | 0.0 | 30.0 | 75.0 |  | 0.0 | 0.0 | 0.0 | 50.0 | 75.0 |
| CYPRINID | Σ | 0 | 0 | 0 | 9 | 1 | 277 | 0 | 0 | 0 | 0 | 2 | 5 |  | 0 | 0 | 0 | 0 | 0 |
|  | MEAN | 0.0 | 0.0 | 0.0 | 0.6 | 0.1 | 12.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 1.3 |  | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
|  | % > 0 | 0.0 | 0.0 | 0.0 | 21.4 | 5.9 | 31.8 | 0.0 | 0.0 | 0.0 | 0.0 | 20.0 | 50.0 |  | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OTHER | Σ | 1 | 4 | 18 | 8 | 2 | 4 | 0 | 3 | 3 | 3 | 6 | 0 |  | 0 | 0 | 0 | 0 | 6 |
|  | MEAN | <0.1 | 0.2 | 0.6 | 0.6 | 0.1 | 0.2 | 0.0 | 0.4 | 0.3 | 0.8 | 0.6 | 0.0 |  | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 |
|  | % > 0 | 4.2 | 14.3 | 31.3 | 28.6 | 11.8 | 18.2 | 0.0 | 25.0 | 20.0 | 25.0 | 30.0 | 0.0 |  | 0.0 | 0.0 | 0.0 | 0.0 | 25.0 |
| ALL FISH | Σ | 1 | 56 | 112 | 72 | 29 | 339 | 0 | 20 | 7 | 13 | 61 | 14 |  | 4 | 3 | 0 | 26 | 11 |
|  | MEAN | <0.1 | 2.7 | 3.5 | 5.1 | 1.7 | 15.4 | 0.0 | 2.5 | 0.7 | 3.3 | 6.1 | 3.5 |  | 1.0 | 0.8 | 0.0 | 4.3 | 2.8 |
|  | % > 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 62.5 | 40.0 | 50.0 | 60.0 | 75.0 |  | 50.0 | 75.0 | 0.0 | 66.7 | 75.0 |

¹ Biweekly periods: 1 = early May 2 = late May 3 = early June 4 = late June
5 = early July 6 = late July 7 = early August 8 = late August.

Table 3.1-6. Cummulative catch (Σ), mean catch per tow, and percentage of tows catching one or more (%>0) larval fish in 1-m plankton nets during regular monitoring at Nanticoke in 1975 (data includes day and night, and midwater and bottom tows).

| LARVAL SPECIES CATEGORY | STATISTIC | WEST STELCO |  |  |  |  |  |  |  | HYDRO INTAKES |  |  |  |  |  |  |  | NGS PLUME |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | BIWEEKLY PERIOD [1] |  |  |  |  |  |  |  | BIWEEKLY PERIOD [1] |  |  |  |  |  |  |  | BIWEEKLY PERIOD [1] |  |  |  |  |  |  |  |
|  |  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|  | No. Tows | 4 | 24 | 16 | 14 | 10 | 6 | 10 | 6 | 0 | 16 | 8 | 6 | 3 | 2 | 6 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| PERCH | Σ | 0 | 0 | 37 | 5 | 0 | 0 | 0 | 0 |  | 0 | 7 | 1 | 0 | 0 | 0 | 0 |  | 0 |  |  |  |  |  |  |
|  | MEAN | 0.0 | 0.0 | 2.3 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 |  | 0.0 | 0.9 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |  | 0.0 |  |  |  |  |  |  |
|  | % > 0 | 0.0 | 0.0 | 68.8 | 21.4 | 0.0 | 0.0 | 0.0 | 0.0 |  | 0.0 | 37.5 | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 |  | 0.0 |  |  |  |  |  |  |
| SMELT | Σ | 1 | 30 | 26 | 88 | 1 | 0 | 1 | 0 |  | 10 | 13 | 106 | 1 | 8 | 1 | 0.0 |  | 7 |  |  |  |  |  |  |
|  | MEAN | 0.3 | 1.3 | 1.6 | 6.3 | 0.1 | 0.0 | 0.1 | 0.0 |  | 0.6 | 1.6 | 17.7 | 0.3 | 4.0 | 0.2 | 0.0 |  | 3.5 |  |  |  |  |  |  |
|  | % > 0 | 25.0 | 33.3 | 56.3 | 71.4 | 10.0 | 0.0 | 10.0 | 0.0 |  | 37.5 | 62.5 | 50.0 | 33.3 | 50.0 | 16.7 | 0.0 |  | 100.0 |  |  |  |  |  |  |
| CLUPEID | Σ | 0 | 0 | 0 | 0 | 5 | 0 | 7 | 3 |  | 0 | 0 | 0 | 0 | 1 | 15 | 2 |  | 0 |  |  |  |  |  |  |
|  | MEAN | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.7 | 0.5 |  | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 2.5 | 1.0 |  | 0.0 |  |  |  |  |  |  |
|  | % > 0 | 0.0 | 0.0 | 0.0 | 0.0 | 40.0 | 0.0 | 30.0 | 50.0 |  | 0.0 | 0.0 | 0.0 | 0.0 | 50.0 | 66.7 | 50.0 |  | 0.0 |  |  |  |  |  |  |
| CYPRINID | Σ | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |  | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  | 0 |  |  |  |  |  |  |
|  | MEAN | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |  | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |  | 0.0 |  |  |  |  |  |  |
|  | % > 0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.0 | 0.0 | 0.0 | 0.0 |  | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |  | 0.0 |  |  |  |  |  |  |
| OTHER | Σ | 0 | 0 | 1 | 4 | 0 | 0 | 0 | 0 |  | 0 | 0 | 1 | 3 | 0 | 0 | 0 |  | 0 |  |  |  |  |  |  |
|  | MEAN | 0.0 | 0.0 | 0.1 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 |  | 0.0 | 0.0 | 0.2 | 1.0 | 0.0 | 0.0 | 0.0 |  | 0.0 |  |  |  |  |  |  |
|  | % > 0 | 0.0 | 0.0 | 6.3 | 21.4 | 0.0 | 0.0 | 0.0 | 0.0 |  | 0.0 | 0.0 | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 |  | 0.0 |  |  |  |  |  |  |
| ALL FISH | Σ | 1 | 30 | 64 | 97 | 7 | 0 | 8 | 3 |  | 10 | 20 | 108 | 4 | 9 | 16 | 2 |  | 7 |  |  |  |  |  |  |
|  | MEAN | 0.3 | 1.3 | 4.0 | 6.9 | 0.7 | 0.0 | 0.8 | 0.5 |  | 0.6 | 2.5 | 18.0 | 1.3 | 4.5 | 2.7 | 1.0 |  | 3.5 |  |  |  |  |  |  |
|  | % > 0 | 25.0 | 33.3 | 81.3 | 71.4 | 50.0 | 0.0 | 30.0 | 50.0 |  | 37.5 | 75.0 | 66.7 | 100.0 | 50.0 | 66.7 | 50.0 |  | 100.0 |  |  |  |  |  |  |

[1] Biweekly periods: 1 = early May 2 = late May 3 = early June 4 = late June
5 = early July 6 = late July 7 = early August 8 = late August

Table 3.1-7. Cummulative catch (Σ), mean catch per tow, and percentage of tows catching one or more (%>0) larval fish in 1-m plankton nets during regular monitoring at Nanticoke in 1976 (data includes day and night, and midwater and bottom tows).

| LARVAL SPECIES CATEGORY | STATISTIC | WEST STELCO | | | | | | | | HYDRO INTAKES | | | | | | | | NGS PLUME | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BIWEEKLY PERIOD[1] | | | | | | | | BIWEEKLY PERIOD[1] | | | | | | | | BIWEEKLY PERIOD[1] | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 3 | 7 |
| | No. Tows | 4 | 16 | 22 | 8 | 8 | 14 | 16 | 16 | 4 | 8 | 10 | 2 | 6 | 8 | 6 | 8 | 4 | 2 | 2 |
| PERCH | Σ | 4 | 4 | 62 | 5 | 1 | 0 | 0 | 0 | 10 | 1 | 5 | 2 | 1 | 0 | 0 | 0 | 77 | 0 | 0 |
| | MEAN | 1.0 | 0.3 | 2.8 | 0.6 | 0.1 | 0.0 | 0.0 | 0.0 | 2.5 | 0.1 | 0.5 | 1.0 | 0.2 | 0.0 | 0.0 | 0.0 | 19.3 | 0.0 | 0.0 |
| | % > 0 | 75.0 | 25.0 | 59.1 | 37.5 | 12.5 | 0.0 | 0.0 | 0.0 | 75.0 | 12.5 | 30.0 | 100.0 | 16.7 | 0.0 | 0.0 | 0.0 | 75.0 | 0.0 | 0.0 |
| SMELT | Σ | 0 | 20 | 747 | 21 | 50 | 104 | 2 | 0 | 0 | 4 | 226 | 15 | 74 | 164 | 2 | 0 | 0 | 32 | 1 |
| | MEAN | 0.0 | 1.3 | 34.0 | 2.6 | 6.3 | 7.4 | 0.1 | 0.0 | 0.0 | 0.5 | 22.6 | 7.5 | 12.3 | 20.5 | 0.3 | 0.0 | 0.0 | 16.0 | 0.5 |
| | % > 0 | 0.0 | 31.3 | 86.4 | 100.0 | 62.5 | 78.6 | 6.3 | 0.0 | 0.0 | 12.5 | 100.0 | 100.0 | 83.3 | 87.5 | 16.7 | 0.0 | 0.0 | 100.0 | 50.0 |
| CLUPEID | Σ | 0 | 0 | 1 | 3 | 5 | 59 | 24 | 1 | 0 | 0 | 0 | 0 | 8 | 47 | 13 | 2 | 0 | 0 | 50 |
| | MEAN | 0.0 | 0.0 | <0.1 | 0.4 | 0.6 | 4.2 | 1.5 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 5.9 | 2.2 | 0.3 | 0.0 | 0.0 | 25.0 |
| | % > 0 | 0.0 | 0.0 | 4.5 | 37.5 | 37.5 | 85.7 | 50.0 | 6.3 | 0.0 | 0.0 | 0.0 | 0.0 | 66.7 | 62.5 | 50.0 | 12.5 | 0.0 | 0.0 | 100.0 |
| CYPRINID | Σ | 0 | 0 | 1 | 5 | 8 | 12 | 9 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 6 | 0 | 0 | 0 | 1 |
| | MEAN | 0.0 | 0.0 | 1.0 | 0.6 | 1.0 | 0.9 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| | % > 0 | 0.0 | 0.0 | 4.5 | 25.0 | 25.0 | 35.7 | 18.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 16.7 | 0.0 | 33.3 | 0.0 | 0.0 | 0.0 | 50.0 |
| OTHER | Σ | 0 | 1 | 5 | 1 | 4 | 5 | 21 | 1 | 0 | 1 | 2 | 1 | 7 | 1 | 0 | 1 | 0 | 0 | 4 |
| | MEAN | 0.0 | 0.1 | 0.2 | 0.1 | 0.5 | 0.4 | 1.3 | 0.1 | 0.0 | 0.1 | 0.2 | 0.5 | 1.2 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 2.0 |
| | % > 0 | 0.0 | 6.3 | 13.6 | 12.5 | 25.0 | 28.6 | 43.8 | 6.3 | 0.0 | 12.5 | 10.0 | 50.0 | 16.7 | 12.5 | 0.0 | 12.5 | 0.0 | 0.0 | 100.0 |
| ALL FISH | Σ | 4 | 25 | 816 | 35 | 68 | 180 | 56 | 2 | 10 | 6 | 233 | 18 | 91 | 212 | 21 | 3 | 77 | 32 | 56 |
| | MEAN | 1.0 | 1.6 | 37.1 | 4.4 | 8.5 | 12.9 | 3.5 | 0.1 | 2.5 | 0.8 | 23.3 | 9.0 | 15.2 | 26.5 | 3.5 | 0.4 | 19.3 | 16.0 | 28.0 |
| | % > 0 | 75.0 | 43.8 | 90.9 | 100.0 | 87.5 | 100.0 | 62.5 | 12.5 | 75.0 | 25.0 | 100.0 | 100.0 | 83.3 | 87.5 | 50.0 | 25.0 | 75.0 | 100.0 | 100.0 |

[1] Biweekly periods: 1 = early May 2 = late May 3 = early June 4 = late June
5 = early July 6 = late July 7 = early August 8 = late August

Table 3.1-8. Cummulative catch (Σ), mean catch per tow, and percentage of tows catching one or more (%>0) larval fish in 1-m plankton nets during regular monitoring at Nanticoke in 1977 (data includes day and night, and midwater and bottom tows).

| LARVAL SPECIES CATEGORY | STATISTIC | WEST STELCO | | | | | | HYDRO INTAKES | | | | | | NGS PLUME | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BIWEEKLY PERIOD[1] | | | | | | BIWEEKLY PERIOD[1] | | | | | | BIWEEKLY PERIOD[1] | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 |
| | No. Tows | 12 | 12 | 12 | 12 | 8 | 12 | 3 | 4 | 4 | 4 | 6 | 4 | 0 | 2 | 8 | 8 | 6 | 8 |
| PERCH | Σ | 0 | 9 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | | 0 | 0 | 2 | 0 | 0 |
| | MEAN | 0.0 | 0.8 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 |
| | % > 0 | 0.0 | 58.3 | 8.3 | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | | 0.0 | 0.0 | 25.0 | 0.0 | 0.0 |
| SMELT | Σ | 2 | 290 | 73 | 77 | 6 | 9 | 0 | 31 | 32 | 30 | 35 | 10 | | 60 | 93 | 56 | 18 | 7 |
| | MEAN | 0.2 | 24.1 | 6.1 | 6.4 | 0.8 | 0.8 | 0.0 | 7.8 | 8.0 | 7.5 | 5.8 | 2.5 | | 30.0 | 11.6 | 7.0 | 3.0 | 0.9 |
| | % > 0 | 16.7 | 100.0 | 91.7 | 83.3 | 37.5 | 16.7 | 0.0 | 100.0 | 100.0 | 100.0 | 66.7 | 50.0 | | 100.0 | 100.0 | 100.0 | 50.0 | 37.5 |
| CLUPEID | Σ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |
| | MEAN | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | % > 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 25.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYPRINID | Σ | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | 0 | 0 | 0 | 1 | 0 |
| | MEAN | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 |
| | % > 0 | 0.0 | 0.0 | 0.0 | 0.0 | 12.5 | 8.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 25.0 | | 0.0 | 0.0 | 0.0 | 16.7 | 0.0 |
| OTHER | Σ | 0 | 0 | 0 | 0 | 10 | 11 | 0 | 0 | 0 | 1 | 20 | 0 | | 0 | 0 | 3 | 7 | 3 |
| | MEAN | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 0.9 | 0.0 | 0.0 | 0.0 | 0.3 | 3.3 | 0.0 | | 0.0 | 0.0 | 0.4 | 1.2 | 0.4 |
| | % > 0 | 0.0 | 0.0 | 0.0 | 0.0 | 50.0 | 16.7 | 0.0 | 0.0 | 0.0 | 25.0 | 33.3 | 0.0 | | 0.0 | 0.0 | 25.0 | 50.0 | 37.5 |
| ALL FISH | Σ | 2 | 299 | 74 | 79 | 17 | 21 | 0 | 31 | 32 | 34 | 55 | 11 | | 60 | 93 | 61 | 26 | 10 |
| | MEAN | 0.2 | 24.9 | 6.2 | 6.6 | 2.1 | 1.8 | 0.0 | 7.8 | 8.0 | 8.5 | 9.2 | 2.8 | | 30.0 | 11.6 | 7.6 | 4.3 | 1.3 |
| | % > 0 | 16.7 | 100.0 | 91.7 | 83.3 | 50.0 | 25.0 | 0.0 | 100.0 | 100.0 | 100.0 | 66.7 | 50.0 | | 100.0 | 100.0 | 100.0 | 66.7 | 50.0 |

[1] Biweekly periods: 1 = early May 2 = late May 3 = early June 4 = late June
5 = early July 6 = late July 7 = early August 8 = late August

Table 3.1-9. Cummulative catch (Σ), mean catch per tow, and percentage of tows catching one or more (%>0) larval fish in 1-m plankton nets during regular monitoring at Nanticoke in 1978 (data includes day and night, and midwater and bottom tows).

| LARVAL SPECIES CATEGORY | STATISTIC | WEST STELCO | | | | | | | HYDRO INTAKES | | | | | | | NGS PLUME | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BIWEEKLY PERIOD[1] | | | | | | | BIWEEKLY PERIOD[1] | | | | | | | BIWEEKLY PERIOD[1] | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | No. Tows | 10 | 12 | 12 | 12 | 11 | 11 | 12 | 10 | 12 | 11 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 11 | 11 | 12 | 11 |
| PERCH | Σ | 0 | 1 | 13 | 6 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 8 | 1 | 0 | 0 |
| | MEAN | 0.0 | 0.1 | 1.1 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.7 | 0.1 | 0.0 | 0.0 |
| | % > 0 | 0.0 | 8.3 | 66.7 | 25.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 18.2 | 8.3 | 8.3 | 0.0 | 0.0 | 0.0 | 0.0 | 16.7 | 63.6 | 9.1 | 0.0 | 0.0 |
| SMELT | Σ | 0 | 800 | 514 | 994 | 106 | 2 | 4 | 0 | 215 | 351 | 1532 | 120 | 71 | 11 | 0 | 147 | 638 | 1457 | 188 | 43 | 47 |
| | MEAN | 0.0 | 66.7 | 42.8 | 82.8 | 9.6 | 0.2 | 0.3 | 0.0 | 17.9 | 31.9 | 127.9 | 10.0 | 5.9 | 0.9 | 0.0 | 12.3 | 53.2 | 132.5 | 17.1 | 3.6 | 4.3 |
| | % > 0 | 0.0 | 100.0 | 100.0 | 100.0 | 63.6 | 18.2 | 25.0 | 0.0 | 91.7 | 100.0 | 83.3 | 75.0 | 50.0 | 41.7 | 0.0 | 75.0 | 83.3 | 100.0 | 81.8 | 41.7 | 36.4 |
| CLUPEID | Σ | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 2 | 0 | 0 | 0 | 1 | 4 | 3 | 0 |
| | MEAN | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.1 | 0.4 | 0.3 | 0.0 |
| | % > 0 | 0.0 | 0.0 | 0.0 | 0.0 | 18.2 | 9.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 41.7 | 0.0 | 16.7 | 0.0 | 0.0 | 0.0 | 9.1 | 27.3 | 16.7 | 0.0 |
| CYPRINID | Σ | 0 | 0 | 0 | 0 | 3 | 1 | 2 | 0 | 0 | 0 | 0 | 6 | 42 | 1 | 0 | 0 | 0 | 0 | 0 | 12 | 2 |
| | MEAN | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 3.5 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.2 |
| | % > 0 | 0.0 | 0.0 | 0.0 | 0.0 | 18.2 | 9.1 | 8.3 | 0.0 | 0.0 | 0.0 | 0.0 | 16.7 | 41.7 | 8.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 25.0 | 18.2 |
| OTHER | Σ | 0 | 2 | 5 | 3 | 8 | 0.0 | 1 | 0 | 0 | 0 | 0 | 2 | 51 | 2 | 0 | 1 | 0 | 0 | 5 | 22 | 2 |
| | MEAN | 0.0 | 1.2 | 0.4 | 0.3 | 0.7 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 4.3 | 0.2 | 0.0 | 0.1 | 0.0 | 0.0 | 0.5 | 1.8 | 0.2 |
| | % > 0 | 0.0 | 16.7 | 33.3 | 25.0 | 45.5 | 0.0 | 8.3 | 0.0 | 0.0 | 0.0 | 0.0 | 16.7 | 58.3 | 16.7 | 0.0 | 8.3 | 0.0 | 0.0 | 27.3 | 33.3 | 9.1 |
| ALL FISH | Σ | 0 | 803 | 532 | 1003 | 119 | 4 | 7 | 0 | 215 | 353 | 1533 | 140 | 164 | 16 | 0 | 148 | 641 | 1466 | 198 | 80 | 51 |
| | MEAN | 0.0 | 66.9 | 44.3 | 83.6 | 10.8 | 0.4 | 0.6 | 0.0 | 17.9 | 32.1 | 127.8 | 11.7 | 13.7 | 1.3 | 0.0 | 12.3 | 53.4 | 133.3 | 18.0 | 6.7 | 4.6 |
| | % > 0 | 0.0 | 100.0 | 100.0 | 100.0 | 63.6 | 36.4 | 33.3 | 0.0 | 91.7 | 100.0 | 83.3 | 75.0 | 66.7 | 50.0 | 0.0 | 75.0 | 83.3 | 100.0 | 81.8 | 41.7 | 45.5 |

[1] Biweekly periods: 1 = early May  2 = late May  3 = early June  4 = late June
5 = early July  6 = late July  7 = early August  8 = late August

Table 3.1-10. Cummulative catch (Σ), mean catch per tow, and percentage of tows catching one or more (%>0) larval fish in 1-m plankton nets during regular monitoring at Nanticoke in 1980 (data includes day and night, and midwater and bottom tows).

| LARVAL SPECIES CATEGORY | STATISTIC | WEST STELCO | | | | | | | | HYDRO INTAKES | | | | | | | | NGS PLUME | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BIWEEKLY PERIOD[1] | | | | | | | | BIWEEKLY PERIOD[1] | | | | | | | | BIWEEKLY PERIOD[1] | | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | No. Tows | 0 | 15 | 18 | 16 | 0 | 26 | 0 | 0 | 0 | 16 | 18 | 18 | 0 | 30 | 0 | 0 | 0 | 14 | 18 | 15 | 0 | 24 | 0 | 0 |
| PERCH | Σ | | 0 | 1 | 0 | | 7 | | | | 0 | 1 | 3 | | 1 | | | | 0 | 4 | 7 | | 0 | | |
| | MEAN | | 0.0 | 0.1 | 0.0 | | 0.3 | | | | 0.0 | 0.1 | 0.2 | | <0.1 | | | | 0.0 | 0.2 | 0.5 | | 0.0 | | |
| | % > 0 | | 0.0 | 5.6 | 0.0 | | 19.2 | | | | 0.0 | 5.6 | 16.7 | | 3.3 | | | | 0.0 | 11.1 | 46.7 | | 0.0 | | |
| SMELT | Σ | | 280 | 109 | 28 | | 5 | | | | 182 | 661 | 84 | | 8 | | | | 125 | 548 | 608 | | 4 | | |
| | MEAN | | 18.7 | 6.1 | 1.8 | | 0.2 | | | | 11.4 | 36.7 | 4.7 | | 0.3 | | | | 8.9 | 30.4 | 40.5 | | 0.2 | | |
| | % > 0 | | 93.3 | 94.4 | 75.0 | | 15.4 | | | | 87.5 | 100.0 | 44.4 | | 16.7 | | | | 100.0 | 94.4 | 100.0 | | 16.7 | | |
| CLUPEID | Σ | | 0 | 0 | 0 | | 1 | | | | 0 | 0 | 0 | | 1 | | | | 0 | 0 | 0 | | 4 | | |
| | MEAN | | 0.0 | 0.0 | 0.0 | | <0.1 | | | | 0.0 | 0.0 | 0.0 | | <0.1 | | | | 0.0 | 0.0 | 0.0 | | 0.2 | | |
| | % > 0 | | 0.0 | 0.0 | 0.0 | | 3.8 | | | | 0.0 | 0.0 | 0.0 | | 3.3 | | | | 0.0 | 0.0 | 0.0 | | 16.7 | | |
| CYPRINID | Σ | | 0 | 0 | 0 | | 0 | | | | 0 | 0 | 0 | | 0 | | | | 0 | 0 | 0 | | 3 | | |
| | MEAN | | 0.0 | 0.0 | 0.0 | | 0.0 | | | | 0.0 | 0.0 | 0.0 | | 0.0 | | | | 0.0 | 0.0 | 0.0 | | 0.1 | | |
| | % > 0 | | 0.0 | 0.0 | 0.0 | | 0.0 | | | | 0.0 | 0.0 | 0.0 | | 0.0 | | | | 0.0 | 0.0 | 0.0 | | 4.2 | | |
| OTHER | Σ | | 1 | 2 | 0 | | 0 | | | | 1 | 0 | 0 | | 0 | | | | 3 | 0 | 0 | | 0 | | |
| | MEAN | | 0.1 | 0.1 | 0.0 | | 0.0 | | | | 0.1 | 0.0 | 0.0 | | 0.0 | | | | 0.2 | 0.0 | 0.0 | | 0.0 | | |
| | % > 0 | | 6.7 | 11.1 | 0.0 | | 0.0 | | | | 6.3 | 0.0 | 0.0 | | 0.0 | | | | 14.3 | 0.0 | 0.0 | | 0.0 | | |
| ALL FISH | Σ | | 281 | 112 | 28 | | 13 | | | | 183 | 662 | 87 | | 10 | | | | 128 | 552 | 615 | | 11 | | |
| | MEAN | | 18.7 | 6.2 | 1.8 | | 0.5 | | | | 11.4 | 36.8 | 4.8 | | 0.3 | | | | 9.1 | 30.7 | 41.0 | | 0.5 | | |
| | % > 0 | | 93.3 | 94.4 | 75.0 | | 30.8 | | | | 87.5 | 100.0 | 44.4 | | 23.3 | | | | 100.0 | 94.4 | 100.0 | | 25.0 | | |

[1] Biweekly periods: 1 = early May 2 = late May 3 = early June 4 = late June
5 = early July 6 = late July 7 = early August 8 = late August

Table 3.1-11. Cummulative catch (Σ), mean catch per tow, and percentage of tows catching one or more (%>0) larval fish in 1-m plankton nets during regular monitoring at Nanticoke in 1981 (data includes day and night, and midwater and bottom tows).

| LARVAL SPECIES CATEGORY | STATISTIC | WEST STELCO | | | | | | | | HYDRO INTAKES | | | | | | | | NGS PLUME | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BIWEEKLY PERIOD [1] | | | | | | | | BIWEEKLY PERIOD [1] | | | | | | | | BIWEEKLY PERIOD [1] | | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | No. Tows | 18 | 18 | 18 | 17 | 0 | 0 | 0 | 0 | 18 | 18 | 17 | 18 | 0 | 0 | 0 | 0 | 12 | 18 | 18 | 16 | 0 | 0 | 0 | 0 |
| PERCH | Σ | 6 | 47 | 28 | 6 | | | | | 2 | 22 | 10 | 9 | | | | | 0 | 127 | 17 | 9 | | | | |
| | MEAN | 0.3 | 2.6 | 1.6 | 0.4 | | | | | 0.1 | 1.2 | 0.6 | 0.5 | | | | | 0.0 | 7.1 | 0.9 | 0.6 | | | | |
| | % > 0 | 33.3 | 50.0 | 61.1 | 23.5 | | | | | 11.1 | 50.0 | 35.3 | 44.4 | | | | | 0.0 | 94.4 | 33.3 | 50.0 | | | | |
| SMELT | Σ | 35 | 260 | 742 | 1231 | | | | | 37 | 873 | 1040 | 2591 | | | | | 3 | 592 | 1020 | 626 | | | | |
| | MEAN | 1.9 | 14.4 | 41.2 | 72.4 | | | | | 2.1 | 48.5 | 61.2 | 143.9 | | | | | 0.3 | 32.9 | 56.7 | 39.1 | | | | |
| | % > 0 | 72.2 | 83.3 | 94.4 | 100.0 | | | | | 83.3 | 100.0 | 88.2 | 100.0 | | | | | 25.0 | 100.0 | 33.3 | 100.0 | | | | |
| CLUPEID | Σ | 0 | 0 | 0 | 0 | | | | | 0 | 0 | 0 | 0 | | | | | 0 | 0 | 0 | 0 | | | | |
| | MEAN | 0.0 | 0.0 | 0.0 | 0.0 | | | | | 0.0 | 0.0 | 0.0 | 0.0 | | | | | 0.0 | 0.0 | 0.0 | 0.0 | | | | |
| | % > 0 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | 0.0 | 0.0 | 0.0 | 0.0 | | | | | 0.0 | 0.0 | 0.0 | 0.0 | | | | |
| CYPRINID | Σ | 0 | 0 | 0 | 6 | | | | | 0 | 0 | 0 | 3 | | | | | 0 | 0 | 0 | 0 | | | | |
| | MEAN | 0.0 | 0.0 | 0.0 | 0.4 | | | | | 0.0 | 0.0 | 0.0 | 0.2 | | | | | 0.0 | 0.0 | 0.0 | 0.0 | | | | |
| | % > 0 | 0.0 | 0.0 | 0.0 | 29.4 | | | | | 0.0 | 0.0 | 0.0 | 16.7 | | | | | 0.0 | 0.0 | 0.0 | 0.0 | | | | |
| OTHER | Σ | 9 | 6 | 2 | 2 | | | | | 14 | 3 | 0 | 0 | | | | | 6 | 3 | 0 | 0 | | | | |
| | MEAN | 0.5 | 0.3 | 0.1 | 0.1 | | | | | 0.8 | 0.2 | 0.0 | 0.0 | | | | | 0.5 | 0.2 | 0.0 | 0.0 | | | | |
| | % > 0 | 27.8 | 33.3 | 5.6 | 5.9 | | | | | 55.6 | 16.7 | 0.0 | 0.0 | | | | | 25.0 | 11.1 | 0.0 | 0.0 | | | | |
| ALL FISH | Σ | 50 | 313 | 772 | 1245 | | | | | 53 | 896 | 1050 | 2603 | | | | | 9 | 722 | 1037 | 635 | | | | |
| | MEAN | 2.8 | 17.4 | 42.9 | 73.2 | | | | | 2.9 | 49.9 | 61.8 | 144.6 | | | | | 0.8 | 40.1 | 57.6 | 39.7 | | | | |
| | % > 0 | 77.8 | 88.9 | 94.4 | 100.0 | | | | | 83.3 | 100.0 | 88.2 | 100.0 | | | | | 41.7 | 100.0 | 33.3 | 100.0 | | | | |

[1] Biweekly periods: 1 = early May 2 = late May 3 = early June 4 = late June
5 = early July 6 = late July 7 = early August 8 = late August

Table 3.1-12. Cummulative catch (Σ), mean catch per tow, and percentage of tows catching one or more (%>0) larval fish in 1-m plankton nets during regular monitoring at Nanticoke in 1982 (data includes day and night, and midwater and bottom tows).

| LARVAL SPECIES CATEGORY | STATISTIC | WEST STELCO | | | | | | | | HYDRO INTAKES | | | | | | | | NGS PLUME | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BIWEEKLY PERIOD [1] | | | | | | | | BIWEEKLY PERIOD [1] | | | | | | | | BIWEEKLY PERIOD [1] | | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | No. Tows | 18 | 18 | 18 | 18 | 18 | 0 | 0 | 0 | 18 | 18 | 18 | 18 | 18 | 0 | 0 | 0 | 18 | 18 | 18 | 18 | 18 | 0 | 0 | 0 |
| PERCH | Σ | 1 | 215 | 21 | 1 | 0 | | | | 0 | 78 | 24 | 5 | 0 | | | | 0 | 14 | 8 | 0 | 0 | | | |
| | MEAN | 0.1 | 11.9 | 1.2 | 0.1 | 0.0 | | | | 0.0 | 4.3 | 1.3 | 0.3 | 0.0 | | | | 0.0 | 0.8 | 0.4 | 0.0 | 0.0 | | | |
| | % > 0 | 5.6 | 100.0 | 50.0 | 5.6 | 0.0 | | | | 0.0 | 88.9 | 38.9 | 11.8 | 0.0 | | | | 0.0 | 44.4 | 27.8 | 0.0 | 0.0 | | | |
| SMELT | Σ | 5 | 754 | 20 | 84 | 5 | | | | 0 | 398 | 175 | 133 | 9 | | | | 1 | 125 | 279 | 214 | 3 | | | |
| | MEAN | 0.3 | 41.9 | 1.1 | 4.7 | 0.3 | | | | 0.0 | 22.1 | 9.7 | 7.8 | 0.5 | | | | 0.1 | 6.9 | 15.5 | 11.9 | 0.2 | | | |
| | % > 0 | 22.2 | 94.4 | 50.0 | 77.8 | 27.8 | | | | 0.0 | 94.4 | 88.9 | 82.4 | 44.4 | | | | 5.6 | 83.3 | 88.9 | 72.2 | 16.7 | | | |
| CLUPEID | Σ | 0 | 0 | 0 | 0 | 0 | | | | 0 | 0 | 0 | 0 | 0 | | | | 0 | 0 | 0 | 0 | 0 | | | |
| | MEAN | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | |
| | % > 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | |
| CYPRINID | Σ | 0 | 0 | 0 | 0 | 0 | | | | 0 | 0 | 2 | 0 | 0 | | | | 0 | 0 | 0 | 0 | 1 | | | |
| | MEAN | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | | | |
| | % > 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | | 0.0 | 0.0 | 11.1 | 0.0 | 0.0 | | | | 0.0 | 0.0 | 0.0 | 0.0 | 5.6 | | | |
| OTHER | Σ | 1 | 3 | 2 | 3 | 1 | | | | 0 | 1 | 2 | 0 | 0 | | | | 0 | 12 | 0 | 0 | 0 | | | |
| | MEAN | 0.1 | 0.2 | 0.1 | 0.2 | 0.1 | | | | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | | | | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | | | |
| | % > 0 | 5.6 | 16.7 | 11.1 | 11.1 | 5.6 | | | | 0.0 | 5.6 | 11.1 | 0.0 | 0.0 | | | | 0.0 | 11.1 | 0.0 | 0.0 | 0.0 | | | |
| ALL FISH | Σ | 7 | 972 | 43 | 88 | 6 | | | | 0 | 477 | 203 | 138 | 9 | | | | 1 | 151 | 287 | 214 | 4 | | | |
| | MEAN | 0.4 | 54.0 | 2.4 | 4.9 | 0.3 | | | | 0.0 | 26.5 | 11.3 | 8.1 | 0.5 | | | | 0.1 | 8.4 | 15.9 | 11.9 | 0.2 | | | |
| | % > 0 | 27.8 | 100.0 | 61.1 | 77.8 | 27.8 | | | | 0.0 | 94.4 | 88.9 | 82.4 | 44.4 | | | | 5.6 | 83.3 | 88.9 | 72.2 | 16.7 | | | |

[1] Biweekly periods: 1 = early May 2 = late May 3 = early June 4 = late June
5 = early July 6 = late July 7 = early August 8 = late August

Table 3.1-13. Cummulative catch (Σ), mean catch per tow, and percentage of tows catching one or more (%>0) larval fish in 1-m plankton nets during regular monitoring at Nanticoke in 1983 (data includes day and night, and midwater and bottom tows).

| LARVAL SPECIES CATEGORY | STATISTIC | WEST STELCO | | | | | | | | HYDRO INTAKES | | | | | | | | NGS PLUME | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BIWEEKLY PERIOD[1] | | | | | | | | BIWEEKLY PERIOD[1] | | | | | | | | BIWEEKLY PERIOD[1] | | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | No. Tows | 18 | 18 | 18 | 18 | | 18 | | | 18 | 18 | 18 | 18 | | 18 | | | 18 | 18 | 18 | 18 | | 18 | | |
| PERCH | Σ | 1 | 0 | 11 | 2 | | 1 | | | 0 | 3 | 3 | 14 | | 0 | | | 0 | 2 | 4 | 5 | | 0 | | |
| | MEAN | 0.1 | 0.0 | 0.6 | 0.1 | | 0.1 | | | 0.0 | 0.2 | 0.2 | 0.8 | | 0.0 | | | 0.0 | 0.1 | 0.2 | 0.3 | | 0.0 | | |
| | % > 0 | 5.6 | 0.0 | 50.0 | 11.1 | | 5.6 | | | 0.0 | 16.7 | 16.7 | 61.1 | | 0.0 | | | 0.0 | 5.6 | 22.2 | 22.2 | | 0.0 | | |
| SMELT | Σ | 99 | 116 | 56 | 24 | | 10 | | | 51 | 107 | 29 | 110 | | 3 | | | 161 | 81 | 64 | 111 | | 22 | | |
| | MEAN | 5.5 | 6.4 | 3.1 | 1.3 | | 0.6 | | | 2.8 | 5.9 | 1.6 | 6.1 | | 0.2 | | | 8.9 | 4.5 | 3.6 | 6.2 | | 1.2 | | |
| | % > 0 | 100.0 | 94.4 | 83.3 | 88.9 | | 16.7 | | | 72.2 | 100.0 | 50.0 | 100.0 | | 11.1 | | | 100.0 | 88.9 | 72.2 | 100.0 | | 50.0 | | |
| CLUPEID | Σ | 0 | 0 | 0 | 0 | | 0 | | | 0 | 0 | 0 | 0 | | 0 | | | 0 | 0 | 0 | 0 | | 0 | | |
| | MEAN | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | | |
| | % > 0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | | |
| CYPRINID | Σ | 0 | 0 | 0 | 2 | | 0 | | | 0 | 0 | 0 | 1 | | 1 | | | 0 | 0 | 0 | 0 | | 1 | | |
| | MEAN | 0.0 | 0.0 | 0.0 | 0.1 | | 0.0 | | | 0.0 | 0.0 | 0.0 | 0.1 | | 0.1 | | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.1 | | |
| | % > 0 | 0.0 | 0.0 | 0.0 | 11.1 | | 0.0 | | | 0.0 | 0.0 | 0.0 | 5.6 | | 5.6 | | | 0.0 | 0.0 | 0.0 | 0.0 | | 5.6 | | |
| OTHER | Σ | 0 | 0 | 1 | 0 | | 0 | | | 0 | 0 | 1 | 0 | | 0 | | | 0 | 0 | 0 | 0 | | 0 | | |
| | MEAN | 0.0 | 0.0 | 0.1 | 0.0 | | 0.0 | | | 0.0 | 0.0 | 0.1 | 0.0 | | 0.0 | | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | | |
| | % > 0 | 0.0 | 0.0 | 5.6 | 0.0 | | 0.0 | | | 0.0 | 0.0 | 5.6 | 0.0 | | 0.0 | | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | | |
| ALL FISH | Σ | 100 | 116 | 68 | 28 | | 11 | | | 51 | 110 | 33 | 125 | | 4 | | | 161 | 83 | 68 | 116 | | 23 | | |
| | MEAN | 5.6 | 6.4 | 3.8 | 1.6 | | 0.6 | | | 2.8 | 6.1 | 1.8 | 6.9 | | 0.2 | | | 8.9 | 4.6 | 3.8 | 6.4 | | 1.3 | | |
| | % > 0 | 100.0 | 94.4 | 88.9 | 88.9 | | 16.7 | | | 72.2 | 100.0 | 55.6 | 100.0 | | 16.7 | | | 100.0 | 88.9 | 77.8 | 100.0 | | 50.0 | | |

[1] Biweekly periods: 1 = early May 2 = late May 3 = early June 4 = late June
5 = early July 6 = late July 7 = early August 8 = late August

Table 3.1-14. Cummulative catch (Σ), mean catch per tow, and percentage of tows catching one or more (%>0) larval fish in ½-m plankton nets at Centre Creek in 1980.

| LARVAL SPECIES CATEGORY | STATISTIC | 50 m OFFSHORE | | | | | | | | 100 m OFFSHORE | | | | | | | | 500 m OFFSHORE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BIWEEKLY PERIOD [1] | | | | | | | | BIWEEKLY PERIOD [1] | | | | | | | | BIWEEKLY PERIOD [1] | | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | No. Tows | 0 | 6 | 5 | 6 | 6 | 11 | 0 | 0 | 0 | 6 | 6 | 6 | 6 | 11 | 0 | 0 | 0 | 5 | 6 | 6 | 6 | 12 | 0 | 0 |
| PERCH | Σ | | 0 | 0 | 2 | 0 | 0 | | | | 0 | 4 | 1 | 0 | 3 | | | | 0 | 1 | 1 | 0 | 0 | | |
| | MEAN | | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | | | | 0.0 | 0.7 | 0.2 | 0.0 | 0.3 | | | | 0.0 | 0.2 | 0.2 | 0.0 | 0.0 | | |
| | % > 0 | | 0.0 | 0.0 | 33.3 | 0.0 | 0.0 | | | | 0.0 | 33.3 | 16.7 | 0.0 | 27.3 | | | | 0.0 | 16.7 | 16.7 | 0.0 | 0.0 | | |
| SMELT | Σ | | 9 | 0 | 0 | 0 | 0 | | | | 14 | 11 | 1 | 0 | 2 | | | | 6 | 15 | 1 | 2 | 0 | | |
| | MEAN | | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | | | | 2.3 | 1.8 | 0.2 | 0.0 | 0.2 | | | | 1.2 | 2.5 | 0.2 | 0.3 | 0.0 | | |
| | % > 0 | | 33.3 | 0.0 | 0.0 | 0.0 | 0.0 | | | | 83.3 | 100.0 | 16.7 | 0.0 | 18.2 | | | | 80.0 | 66.7 | 16.7 | 33.3 | 0.0 | | |
| CLUPEID | Σ | | 0 | 0 | 0 | 0 | 6 | | | | 0 | 0 | 0 | 0 | 8 | | | | 0 | 0 | 1 | 0 | 11 | | |
| | MEAN | | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | | | | 0.0 | 0.0 | 0.2 | 0.0 | 0.9 | | |
| | % > 0 | | 0.0 | 0.0 | 0.0 | 0.0 | 36.4 | | | | 0.0 | 0.0 | 0.0 | 0.0 | 36.4 | | | | 0.0 | 0.0 | 16.7 | 0.0 | 33.3 | | |
| CYRPINID | Σ | | 0 | 0 | 0 | 2 | 12 | | | | 0 | 0 | 0 | 0 | 13 | | | | 0 | 0 | 1 | 0 | 11 | | |
| | MEAN | | 0.0 | 0.0 | 0.0 | 0.3 | 1.1 | | | | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | | | | 0.0 | 0.0 | 0.2 | 0.0 | 0.9 | | |
| | % > 0 | | 0.0 | 0.0 | 0.0 | 16.7 | 36.4 | | | | 0.0 | 0.0 | 0.0 | 0.0 | 54.5 | | | | 0.0 | 0.0 | 16.7 | 0.0 | 50.0 | | |
| OTHER | Σ | | 0 | 0 | 0 | 0 | 1 | | | | 0 | 0 | 0 | 0 | 2 | | | | 0 | 0 | 0 | 0 | 0 | | |
| | MEAN | | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| | % > 0 | | 0.0 | 0.0 | 0.0 | 0.0 | 9.1 | | | | 0.0 | 0.0 | 0.0 | 0.0 | 9.1 | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | |
| ALL FISH | Σ | | 9 | 0 | 2 | 2 | 19 | | | | 14 | 15 | 2 | 0 | 28 | | | | 6 | 16 | 4 | 2 | 22 | | |
| | MEAN | | 1.5 | 0.0 | 0.3 | 0.3 | 1.7 | | | | 2.3 | 2.5 | 0.3 | 0.0 | 2.5 | | | | 1.2 | 2.7 | 0.7 | 0.3 | 1.8 | | |
| | % > 0 | | 33.3 | 0.0 | 33.3 | 16.7 | 63.6 | | | | 83.3 | 100.0 | 33.3 | 0.0 | 100.0 | | | | 80.0 | 66.7 | 66.7 | 33.3 | 83.3 | | |

[1] Biweekly periods: 1 = early May 2 = late May 3 = early June 4 = late June
5 = early July 6 = late July 7 = early August 8 = late August

Table 3.1-15. Cummulative catch (Σ), mean catch per tow, and percentage of tows catching one or more (%>0) larval fish in ½-m plankton nets at Centre Creek in 1981.

| LARVAL SPECIES CATEGORY | STATISTIC | 50 m OFFSHORE | | | | | 100 m OFFSHORE | | | | | 500 m OFFSHORE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BIWEEKLY PERIOD[1] | | | | | BIWEEKLY PERIOD[1] | | | | | BIWEEKLY PERIOD[1] | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| | No. Tows | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 |
| PERCH | Σ | 0 | 1 | 20 | 47 | 0 | 0 | 0 | 5 | 43 | 1 | 1 | 3 | 3 | 14 | 0 |
| | MEAN | 0.0 | 0.2 | 3.3 | 7.8 | 0.0 | 0.0 | 0.0 | 0.8 | 7.2 | 0.2 | 0.2 | 0.5 | 0.6 | 2.3 | 0.0 |
| | % > 0 | 0.0 | 16.7 | 83.3 | 83.3 | 0.0 | 0.0 | 0.0 | 50.0 | 83.3 | 16.7 | 16.7 | 33.3 | 60.0 | 50.0 | 0.0 |
| SMELT | Σ | 1 | 0 | 14 | 162 | 0 | 3 | 1 | 40 | 40 | 0 | 1 | 4 | 37 | 59 | 12 |
| | MEAN | 0.2 | 0.0 | 2.3 | 27.0 | 0.0 | 0.5 | 0.2 | 6.7 | 6.7 | 0.0 | 0.2 | 0.7 | 7.4 | 9.8 | 2.0 |
| | % > 0 | 16.7 | 0.0 | 83.3 | 83.3 | 0.0 | 33.3 | 16.7 | 66.7 | 100.0 | 0.0 | 16.7 | 50.0 | 80.0 | 100.0 | 50.0 |
| CLUPEID | Σ | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | MEAN | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | % > 0 | 0.0 | 0.0 | 0.0 | 0.0 | 33.3 | 0.0 | 0.0 | 0.0 | 0.0 | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYPRINID | Σ | 0 | 9 | 5 | 21 | 8 | 0 | 1 | 2 | 33 | 11 | 0 | 1 | 0 | 7 | 1 |
| | MEAN | 0.0 | 1.5 | 0.8 | 3.5 | 1.3 | 0.0 | 0.2 | 0.3 | 5.5 | 1.8 | 0.0 | 0.2 | 0.0 | 1.2 | 0.2 |
| | % > 0 | 0.0 | 66.7 | 33.3 | 83.3 | 83.3 | 0.0 | 16.7 | 33.3 | 100.0 | 66.7 | 0.0 | 16.7 | 0.0 | 50.0 | 16.7 |
| OTHER | Σ | 2 | 0 | 4 | 0 | 0 | 2 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 7 | 0 |
| | MEAN | 0.3 | 0.0 | 0.7 | 0.0 | 0.0 | 0.3 | 0.0 | 0.3 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 0.0 |
| | % > 0 | 33.3 | 0.0 | 50.0 | 0.0 | 0.0 | 33.3 | 0.0 | 33.3 | 33.3 | 0.0 | 0.0 | 0.0 | 0.0 | 66.7 | 0.0 |
| ALL FISH | Σ | 3 | 10 | 43 | 230 | 11 | 5 | 2 | 49 | 118 | 13 | 2 | 8 | 40 | 87 | 13 |
| | MEAN | 0.5 | 1.7 | 7.2 | 38.3 | 1.8 | 0.8 | 0.3 | 8.2 | 19.7 | 2.2 | 0.3 | 1.3 | 8.0 | 14.5 | 2.2 |
| | % > 0 | 50.0 | 66.7 | 100.0 | 83.3 | 83.3 | 33.3 | 16.7 | 83.3 | 100.0 | 83.3 | 33.3 | 66.7 | 80.0 | 100.0 | 66.7 |

[1] Biweekly periods: 1 = early May 2 = late May 3 = early June 4 = late June
5 = early July 6 = late July 7 = early August 8 = late August

Table 3.1-16. Cummulative catch (Σ), mean catch per tow, and percentage of tows catching one or more (%>0) larval fish in ½-m plankton nets at Centre Creek in 1982.

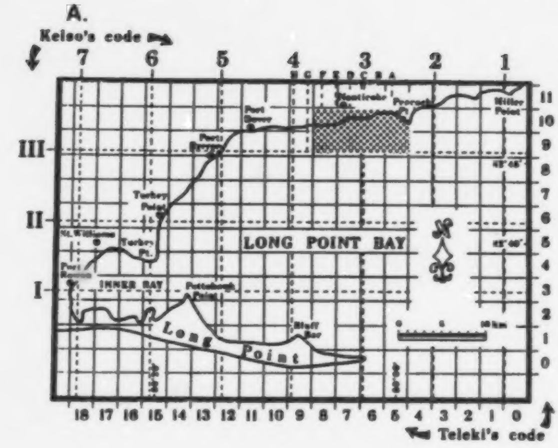
| LARVAL SPECIES CATEGORY | STATISTIC | 50 m OFFSHORE |  |  |  |  | 100 m OFFSHORE |  |  |  |  | 500 m OFFSHORE |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | BIWEEKLY PERIOD ¹ |  |  |  |  | BIWEEKLY PERIOD ¹ |  |  |  |  | BIWEEKLY PERIOD ¹ |  |  |  |  |
|  |  | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
|  | No. Tows | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| PERCH | Σ | 0 | 1 | 10 | 2 | 0 | 0 | 0 | 5 | 1 | 0 | 0 | 12 | 5 | 1 | 0 |
|  | MEAN | 0.0 | 0.2 | 1.7 | 0.3 | 0.0 | 0.0 | 0.0 | 0.8 | 0.2 | 0.0 | 0.0 | 2.0 | 0.8 | 0.2 | 0.0 |
|  | % > 0 | 0.0 | 16.7 | 66.7 | 33.3 | 0.0 | 0.0 | 0.0 | 50.0 | 16.7 | 0.0 | 0.0 | 66.7 | 66.7 | 16.7 | 0.0 |
| SMELT | Σ | 40 | 1 | 0 | 22 | 4 | 2 | 6 | 1 | 17 | 7 | 4 | 60 | 17 | 46 | 36 |
|  | MEAN | 6.7 | 0.2 | 0.0 | 3.7 | 0.7 | 0.3 | 1.0 | 0.2 | 2.8 | 0.2 | 0.7 | 10.0 | 2.8 | 7.7 | 6.0 |
|  | % > 0 | 83.3 | 16.7 | 0.0 | 83.3 | 50.0 | 33.3 | 50.0 | 16.7 | 100.0 | 83.3 | 50.0 | 100.0 | 50.0 | 100.0 | 50.0 |
| CLUPEID | Σ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  | MEAN | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
|  | % > 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CYPRINID | Σ | 0 | 0 | 2 | 3 | 5 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 2 |
|  | MEAN | 0.0 | 0.0 | 0.3 | 0.5 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
|  | % > 0 | 0.0 | 0.0 | 33.3 | 33.3 | 66.7 | 0.0 | 0.0 | 0.0 | 0.0 | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 | 16.7 |
| OTHER | Σ | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
|  | MEAN | 0.0 | 0.0 | 0.2 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
|  | % > 0 | 0.0 | 0.0 | 16.7 | 50.0 | 0.0 | 0.0 | 0.0 | 0.0 | 16.7 | 0.0 | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| ALL FISH | Σ | 40 | 2 | 13 | 30 | 9 | 2 | 6 | 6 | 19 | 12 | 5 | 72 | 22 | 47 | 38 |
|  | MEAN | 6.7 | 0.3 | 2.2 | 5.0 | 1.5 | 0.3 | 1.0 | 1.0 | 3.2 | 2.0 | 0.8 | 12.0 | 3.7 | 7.8 | 6.3 |
|  | % > 0 | 83.3 | 33.3 | 83.3 | 83.3 | 83.3 | 33.3 | 50.0 | 66.7 | 100.0 | 83.3 | 50.0 | 100.0 | 83.3 | 100.0 | 50.0 |

[1] Biweekly periods: 1 = early May 2 = late May 3 = early June 4 = late June
5 = early July 6 = late July 7 = early August 8 = late August

Table 3.1-17. Cummulative catch (Σ), mean catch per tow, and percentage of tows catching one or more (%>0) larval fish in ½-m plankton nets at Centre Creek in 1983.

| LARVAL SPECIES CATEGORY | STATISTIC | 50 m OFFSHORE | | | | | | | | 100 m OFFSHORE | | | | | | | | 500 m OFFSHORE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BIWEEKLY PERIOD [1] | | | | | | | | BIWEEKLY PERIOD [1] | | | | | | | | BIWEEKLY PERIOD [1] | | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | No. Tows | 6 | 6 | 6 | 6 | 6 | 6 | 0 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 0 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 0 | 6 |
| PERCH | Σ | 0 | 38 | 45 | 0 | 5 | 7 | | 1 | 0 | 14 | 20 | 2 | 0 | 1 | | 0 | 0 | 2 | 5 | 2 | 0 | 1 | | 0 |
| | MEAN | 0.0 | 6.3 | 7.5 | 0.0 | 0.8 | 1.2 | | 0.2 | 0.0 | 2.3 | 3.3 | 0.3 | 0.0 | 0.2 | | 0.0 | 0.0 | 0.3 | 0.8 | 0.3 | 0.0 | 0.2 | | 0.0 |
| | % > 0 | 0.0 | 100.0 | 100.0 | 0.0 | 50.0 | 66.7 | | 16.7 | 0.0 | 66.7 | 100.0 | 33.3 | 0.0 | 16.7 | | 0.0 | 0.0 | 33.3 | 66.7 | 16.7 | 0.0 | 16.7 | | 0.0 |
| SMELT | Σ | 13 | 11 | 3 | 1 | 53 | 3 | | 0 | 17 | 6 | 3 | 7 | 6 | 2 | | 0 | 35 | 4 | 3 | 10 | 4 | 0 | | 1 |
| | MEAN | 2.2 | 1.8 | 0.5 | 0.2 | 8.8 | 0.5 | | 0.0 | 2.8 | 1.0 | 0.5 | 1.2 | 1.0 | 0.3 | | 0.0 | 5.8 | 0.7 | 0.5 | 1.7 | 0.7 | 0.0 | | 0.0 |
| | % > 0 | 100.0 | 100.0 | 50.0 | 16.7 | 83.3 | 33.3 | | 0.0 | 66.7 | 50.0 | 33.3 | 66.7 | 66.7 | 33.3 | | 0.0 | 100.0 | 50.0 | 33.3 | 66.7 | 50.0 | 0.0 | | 16.7 |
| CLUPEID | Σ | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| | MEAN | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 |
| | % > 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 |
| CYPRINID | Σ | 0 | 0 | 0 | 3 | 4 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| | MEAN | 0.0 | 0.0 | 0.0 | 0.5 | 0.7 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 |
| | % > 0 | 0.0 | 0.0 | 0.0 | 16.7 | 50.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 |
| OTHER | Σ | 0 | 0 | 1 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 1 | 0 | 0 | | 5 |
| | MEAN | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | | 0.8 |
| | % > 0 | 0.0 | 0.0 | 16.7 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 | 0.0 | 16.7 | 0.0 | 0.0 | | 66.7 |
| ALL FISH | Σ | 13 | 49 | 49 | 4 | 62 | 10 | | 1 | 17 | 20 | 23 | 9 | 6 | 3 | | 0 | 35 | 6 | 8 | 13 | 4 | 1 | | 6 |
| | MEAN | 2.2 | 8.2 | 8.2 | 0.7 | 10.3 | 1.7 | | 0.2 | 2.8 | 3.3 | 3.8 | 1.5 | 1.0 | 0.5 | | 0.0 | 5.8 | 1.0 | 1.3 | 2.2 | 0.7 | 0.2 | | 1.0 |
| | % > 0 | 100.0 | 100.0 | 100.0 | 33.3 | 100.0 | 66.7 | | 16.7 | 66.7 | 83.3 | 100.0 | 83.3 | 66.7 | 50.0 | | 0.0 | 100.0 | 66.7 | 66.7 | 83.3 | 50.0 | 15.7 | | 66.7 |

[1] Biweekly periods: 1 = early May 2 = late May 3 = early June 4 = late June
5 = early July 6 = late July 7 = early August 8 = late August


A.
Kelso's code
7
6
5
4
3
2
1
H G F E D C B A
III
II
I
11
10
9
8
7
6
5
4
3
2
1
0
Nanticoke
Port Dover
Port Ryerse
Turkey Point
St. Williams
Turkey Pt.
Port Rowan
INNER BAY
Pottahawk Point
LONG POINT BAY
Long Point
Bluff Bar
Miller Point
0 5 10 km
18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
Teleki's code

B. Enlargement of Study Area (shaded area above)

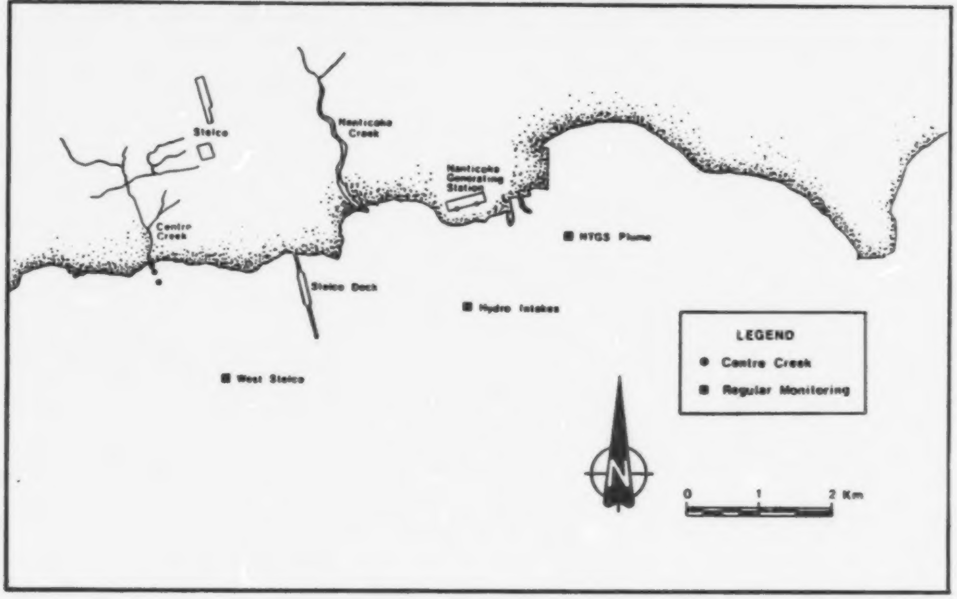
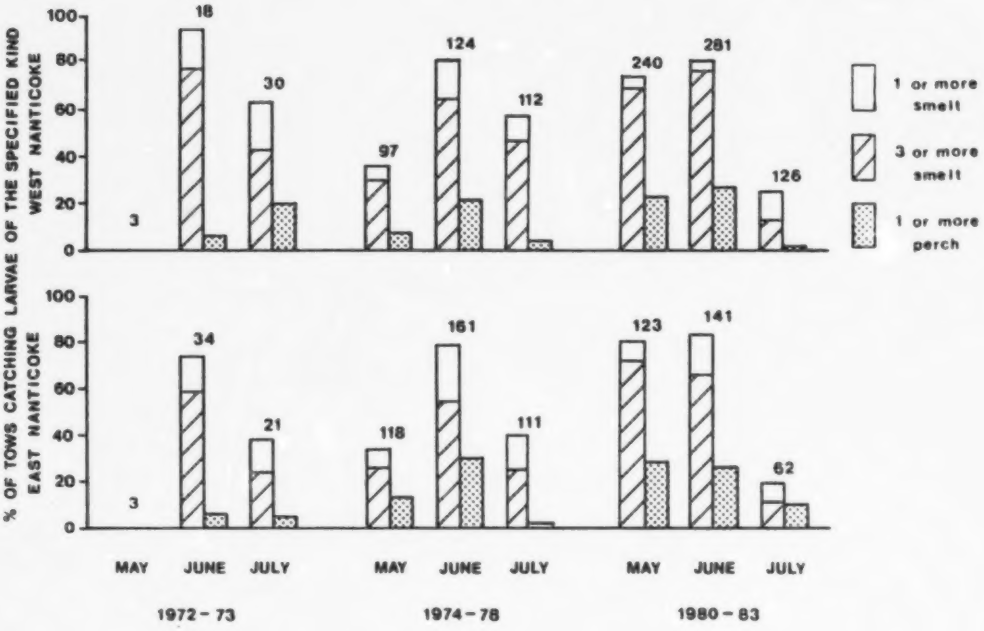
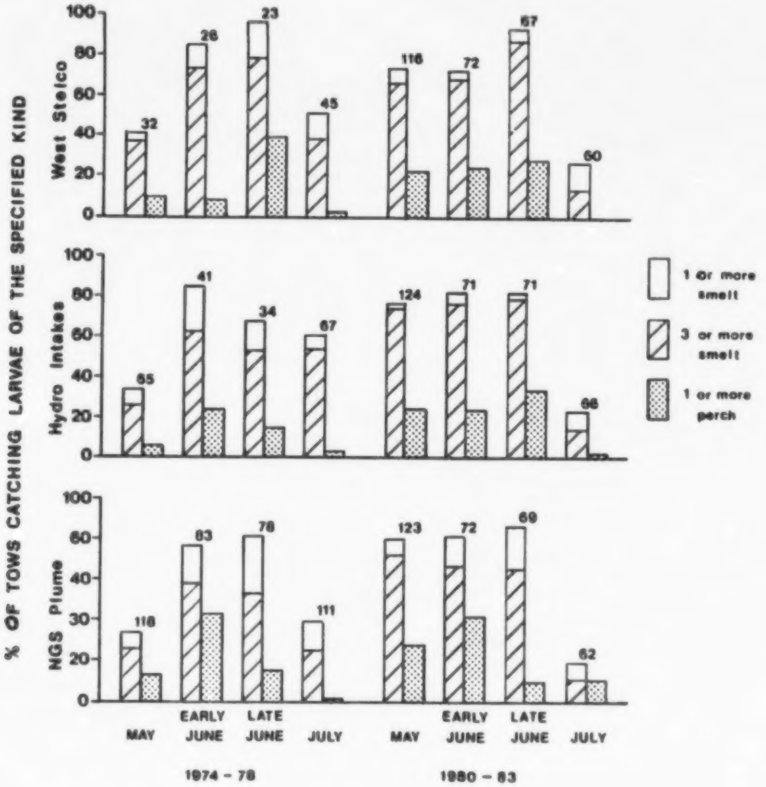

Stelco
Nanticoke Creek
Nanticoke Generating Station
Centre Creek
NTGS Plume
Stelco Dock
Hydro Intakes
West Stelco
LEGEND
Centre Creek
Regular Monitoring
N
0
1
2 Km

Figure 3.1-1. Long Point Bay (A) showing grid systems of Kelso (1971-1972) and Teleki (1973-1983). Standardized larval fish locations sampled in 1980 are shown in enlargement B.



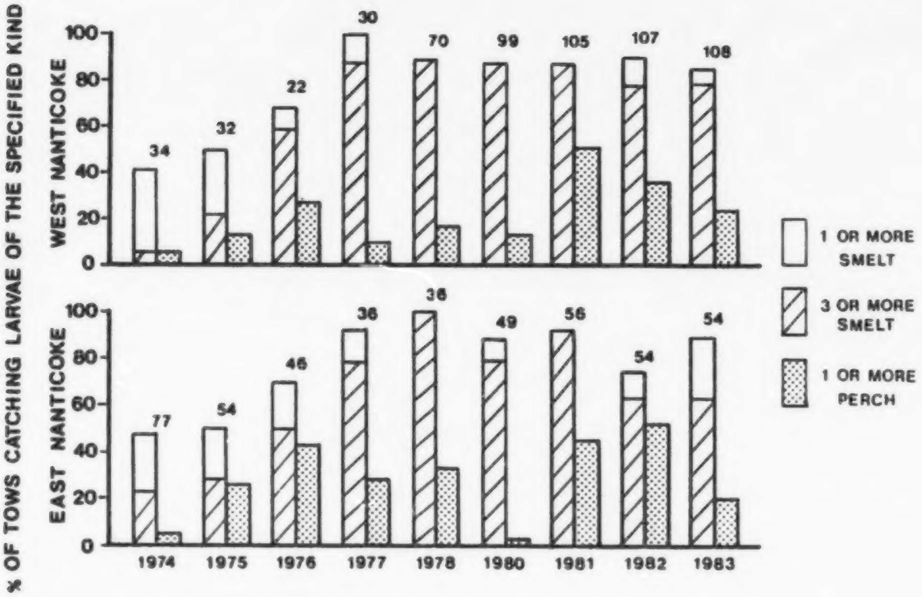
| Source of Variation | df | Chi-square ($\chi^2$) statistics by species and catch response category (= 0 vs > 0 and ≤ 2 vs > 2) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Smelt (= 0 vs > 0) | | Smelt (≤ 2 vs > 2) | | Yellow Perch (= 0 vs > 0) | |
| | | $\chi^2$ | P | $\chi^2$ | P | $\chi^2$ | P |
| Period | 2 | 5.05 | 0.0799 | 7.66 | 0.0217 | 4.86 | 0.0879 |
| Season | 2 | 81.96 | 0.0001 | 95.91 | 0.0001 | 19.09 | 0.0001 |
| Location | 1 | 2.21 | 0.1374 | 2.76 | 0.0965 | 0.15 | 0.7007 |
| Per * Sea | 4 | 107.40 | 0.0001 | 92.44 | 0.0001 | 24.26 | 0.0001 |
| Per * Loc | 2 | 3.04 | 0.2186 | 1.31 | 0.5193 | 3.84 | 0.1468 |
| Sea * Loc | 2 | 0.95 | 0.6217 | 0.69 | 0.7069 | 0.12 | 0.9398 |
| Per * Sea * Loc | 4 | 1.10 | 0.8949 | 2.22 | 0.6953 | 8.38 | 0.0788 |

Figure 3.1-2. Results of Logit analysis testing the significance of period, season, and location (West Nanticoke = West Stelco and Hydro Intakes; East Nanticoke = NGS Plume) on catches of larval smelt and yellow perch in metre nets during regular monitoring at Nanticoke, 1972-1983 (day and night, midwater and bottom tows). Values above histogram bars are the No. of tows sampled.



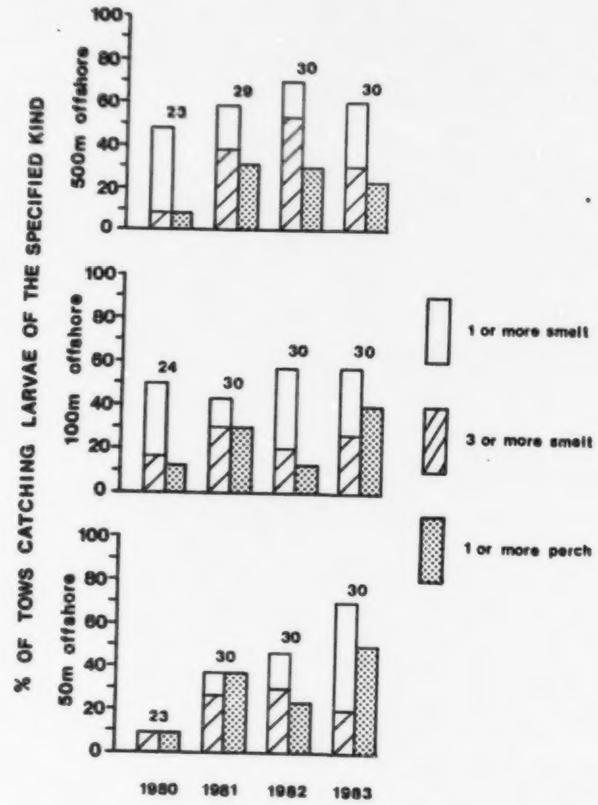
| Source of Variation | | Chi-square ($\chi^2$) statistics by species and catch response category (= 0 vs > 0 and $\leq$ 2 vs > 2) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Smelt (= 0 vs > 0) | | Smelt ($\leq$ 2 vs > 2) | | Yellow Perch (= 0 vs > 0) | |
| | df | $\chi^2$ | P | $\chi^2$ | P | $\chi^2$ | P |
| Period | 1 | 0.50 | 0.4807 | 7.12 | 0.0076 | 3.92 | 0.0476 |
| Season | 3 | 169.40 | 0.0001 | 156.30 | 0.0001 | 45.10 | 0.0001 |
| Location | 2 | 4.21 | 0.1221 | 13.95 | 0.0009 | 1.73 | 0.4209 |
| Per * Sea | 3 | 100.40 | 0.0001 | 92.40 | 0.0001 | 7.77 | 0.0511 |
| Per * Loc | 2 | 2.74 | 0.2535 | 2.32 | 0.3139 | 0.76 | 0.6033 |
| Sea * Loc | 6 | 12.97 | 0.0435 | 9.57 | 0.1439 | 29.17 | 0.0001 |
| Per * Sea * Loc | 6 | 4.36 | 0.6283 | 6.41 | 0.3784 | 12.55 | 0.0508 |

Figure 3.1-3. Results of Logit analysis testing the significance of period, season and location on catches of smelt and yellow perch larvae in metre nets during regular monitoring at Nanticoke, 1974-1983 (day and night, midwater and bottom tows). Values above histogram bars are the No. of tows sampled.



| Source of Variation | df | Chi-square ($\chi^2$) statistics by species and catch response category (= 0 vs > 0 and ≤ 2 vs > 2) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Smelt (= 0 vs > 0) | | Smelt (≤ 2 vs > 2) | | Yellow Perch (= 0 vs > 0) | |
| | | $\chi^2$ | P | $\chi^2$ | P | $\chi^2$ | P |
| Year | 8 | 117.90 | 0.0001 | 158.90 | 0.0001 | 82.72 | 0.0001 |
| Location | 1 | 0.22 | 0.6388 | 0.59 | 0.4437 | 0.90 | 0.3423 |
| Yr * Loc | 8 | 8.13 | 0.4211 | 16.48 | 0.0360 | 15.07 | 0.0578 |

Figure 3.1-4. Results of Logit analysis testing the significance of year and location (West Nanticoke = West Stelco and Hydro Intakes; East Nanticoke = NGS Plume) on catches of smelt and yellow perch larvae in metre nets during regular monitoring at Nanticoke, 1974-1983 (late May to late June; day and night, midwater and bottom tows). Values above histogram bars are the No. of tows sampled.

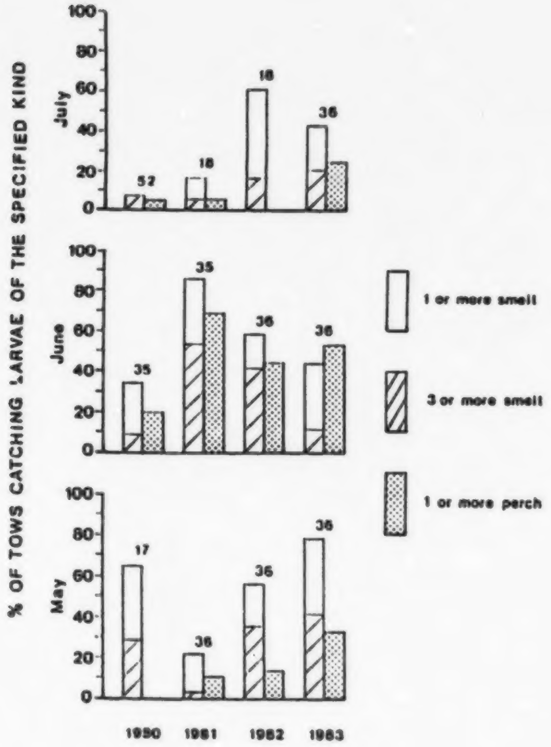


| Source of Variation | df | Chi-square statistics by species and catch response category (= 0 vs > 0 and ≤ 2 vs > 2) | | |
|---|---|---|---|---|
| | | Smelt = 0 vs > 0 | Smelt ≤ 2 vs > 2 | Perch = 0 vs > 0 |
| Year | 3 | 14.33 [2] | 10.46 [1] | 15.91 [2] |
| DFS | 2 | 8.59 [1] | 2.08 | 0.72 |
| Yr * DFS | 6 | 11.01 | 5.34 | 5.97 |

[1] P ≤ 0.05

[2] P ≤ 0.01

Figure 3.1-5. Results of Logit analysis testing the significance of year and distance from shore (DFS) on catches of smelt and yellow perch larvae in ½-m plankton nets offshore of Centre Creek's outfall, 1980-1983 (early May to early July). Values above histogram bars are the number of tows sampled.



| Source of Variation | df | Chi-square statistics by species and catch response category (= 0 vs > 0 and ≤ 2 vs > 2) | | |
|---|---|---|---|---|
| | | Smelt<br>= 0 vs > 0 | Smelt<br>≤ 2 vs > 2 | Perch<br>= 0 vs > 0 |
| Year | 3 | 15.00 [2] | 10.05 [1] | 17.06 [2] |
| Season | 2 | 18.31 [3] | 11.96 [2] | 33.26 [3] |
| Yr * Sea | 6 | 46.20 [3] | 32.94 [3] | 10.01 |

[1] $P \leq 0.05$

[2] $P \leq 0.01$

[3] $P \leq 0.0001$

Figure 3.1-6. Results of Logit analysis testing the significane of year and season (month) on catches of smelt and yellow perch larvae in ½-m plankton nets offshore (50,100 and 500 m) of Centre Creek's outfall, 1980-1983. Values above histogram bars are the No. of tows sampled.

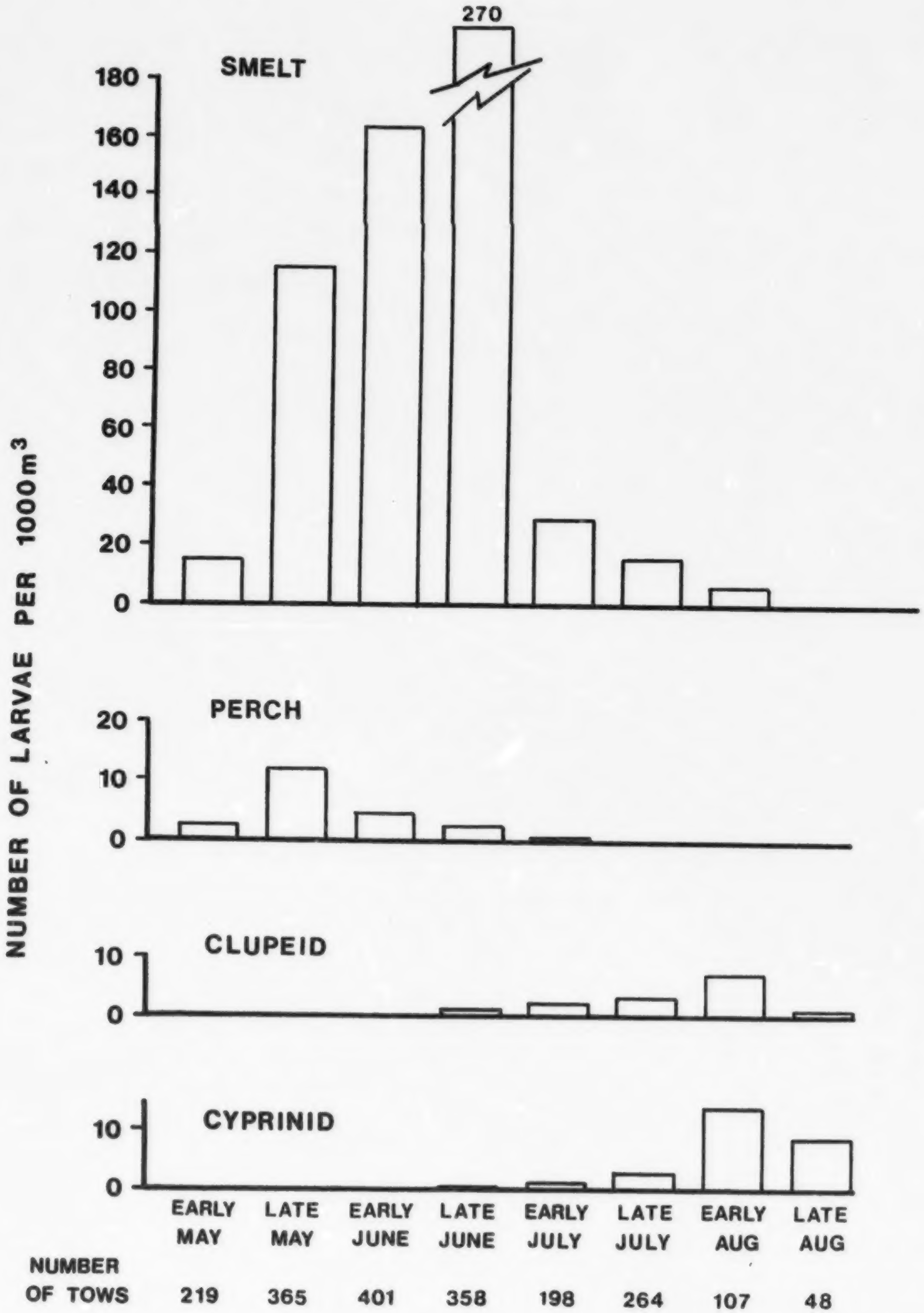


Figure 3.1-7. Numbers of larval fish per 1000 m$^3$ of lake water caught in metre nets during regular monitoring at Nanticoke from early May to late August (1972-1983).

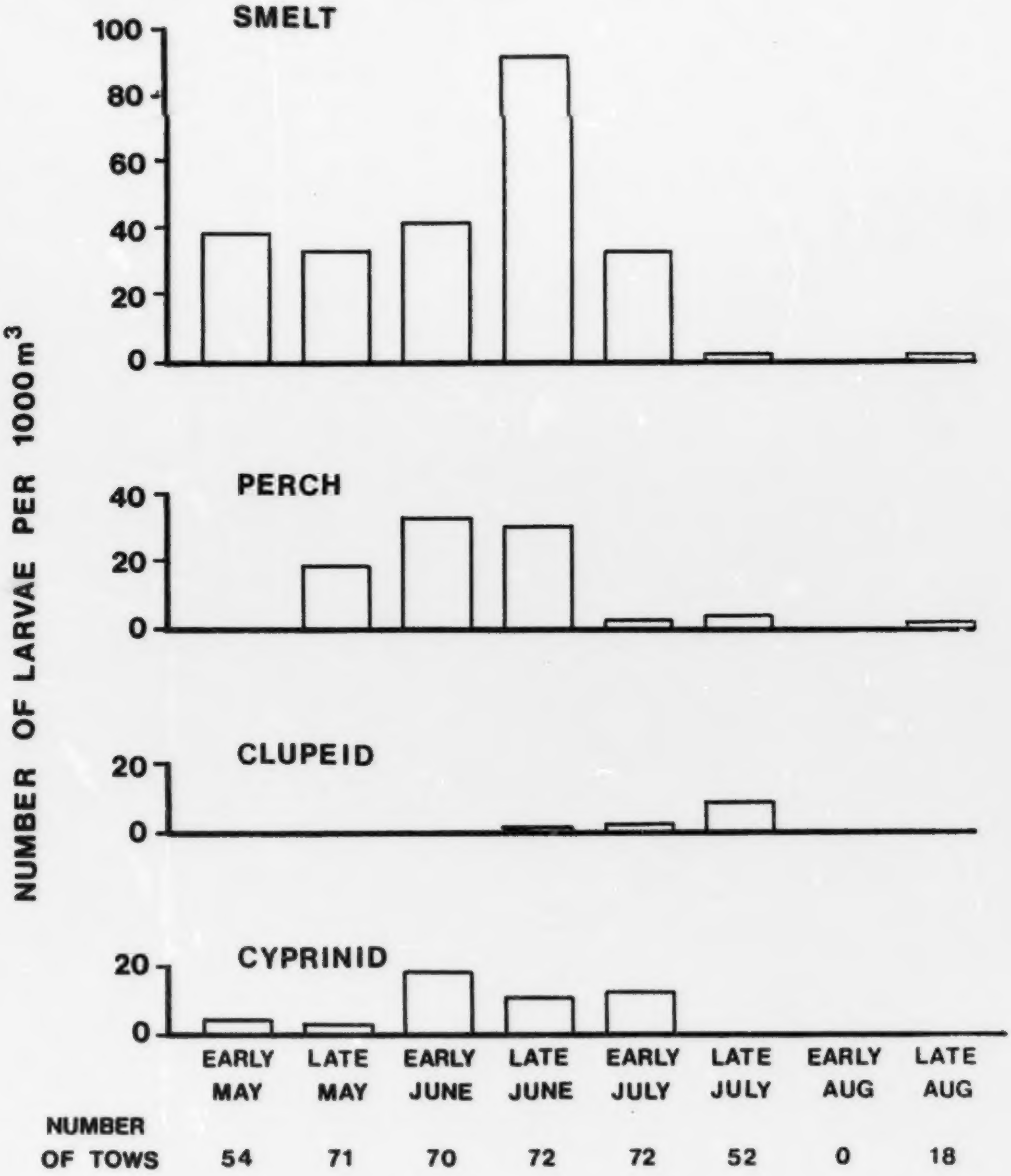


Figure 3.1-8. Numbers of larval fish per 1000 m³ of lake water caught in ½-m plankton nets offshore of Centre Creek from early May to late August (1980-1983).

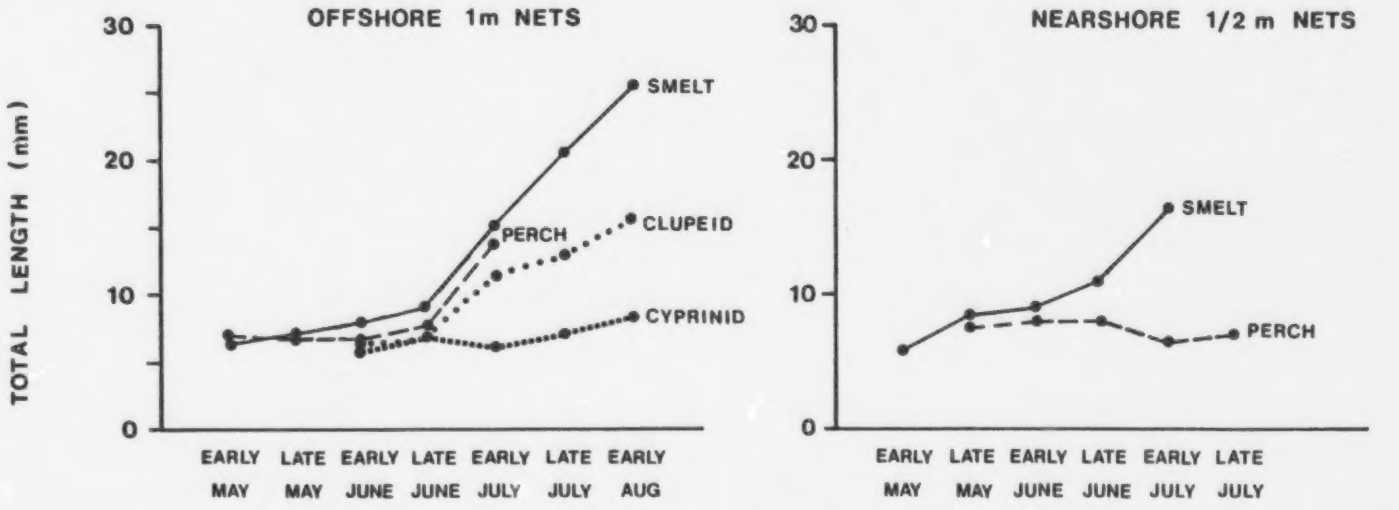


Figure 3.1-9. Growth of larval fish caught in offshore (1-m nets, 1972-1984 and nearshore) (½-m nets, 1980-1983) waters at Nanticoke.

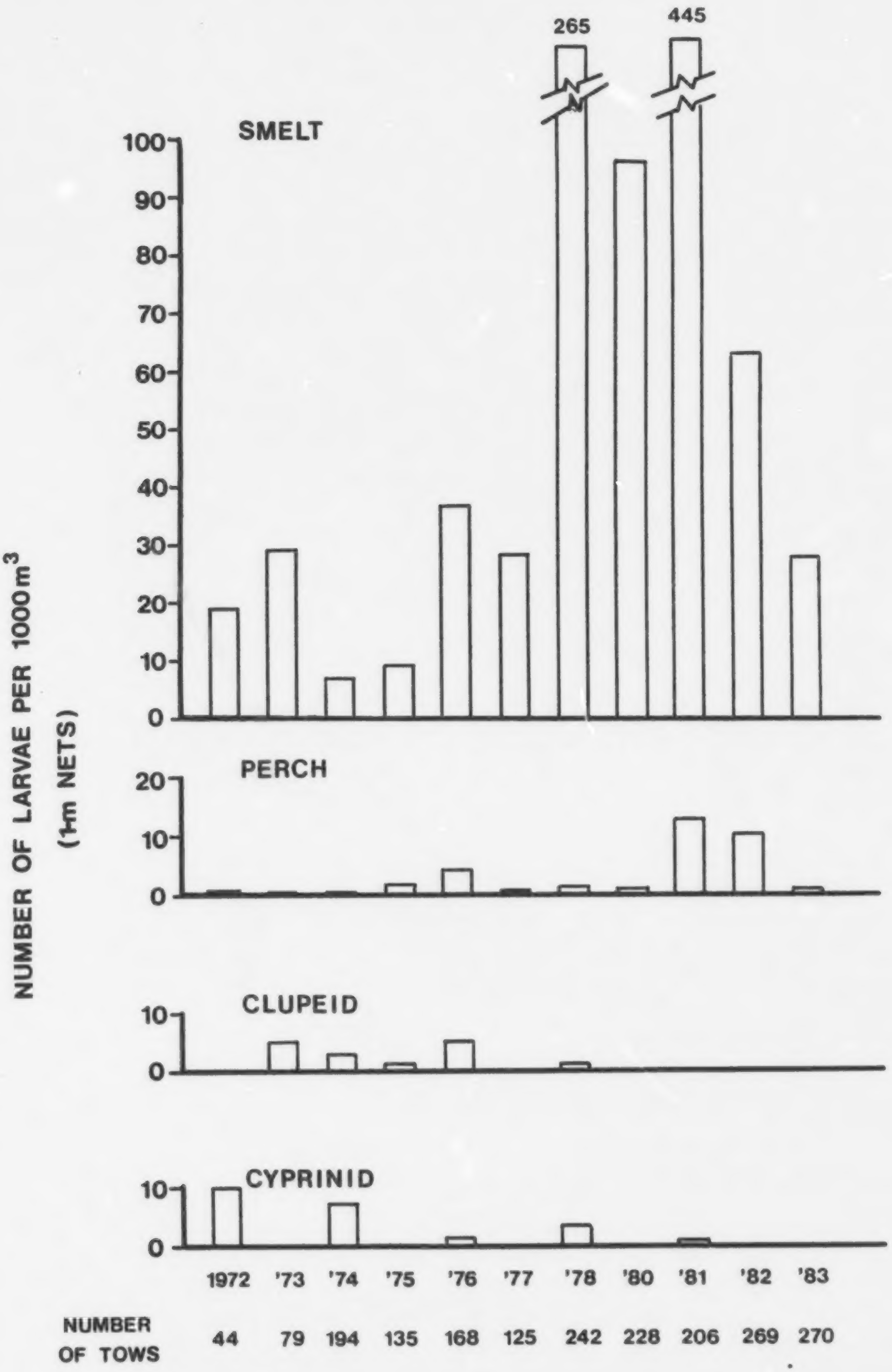


Figure 3.1-10. Numbers of larval fish per 1000 $m^3$ of lake water caught in metre nets during regular monitoring at Nanticoke in 1972 to 1983 (early May to late August).

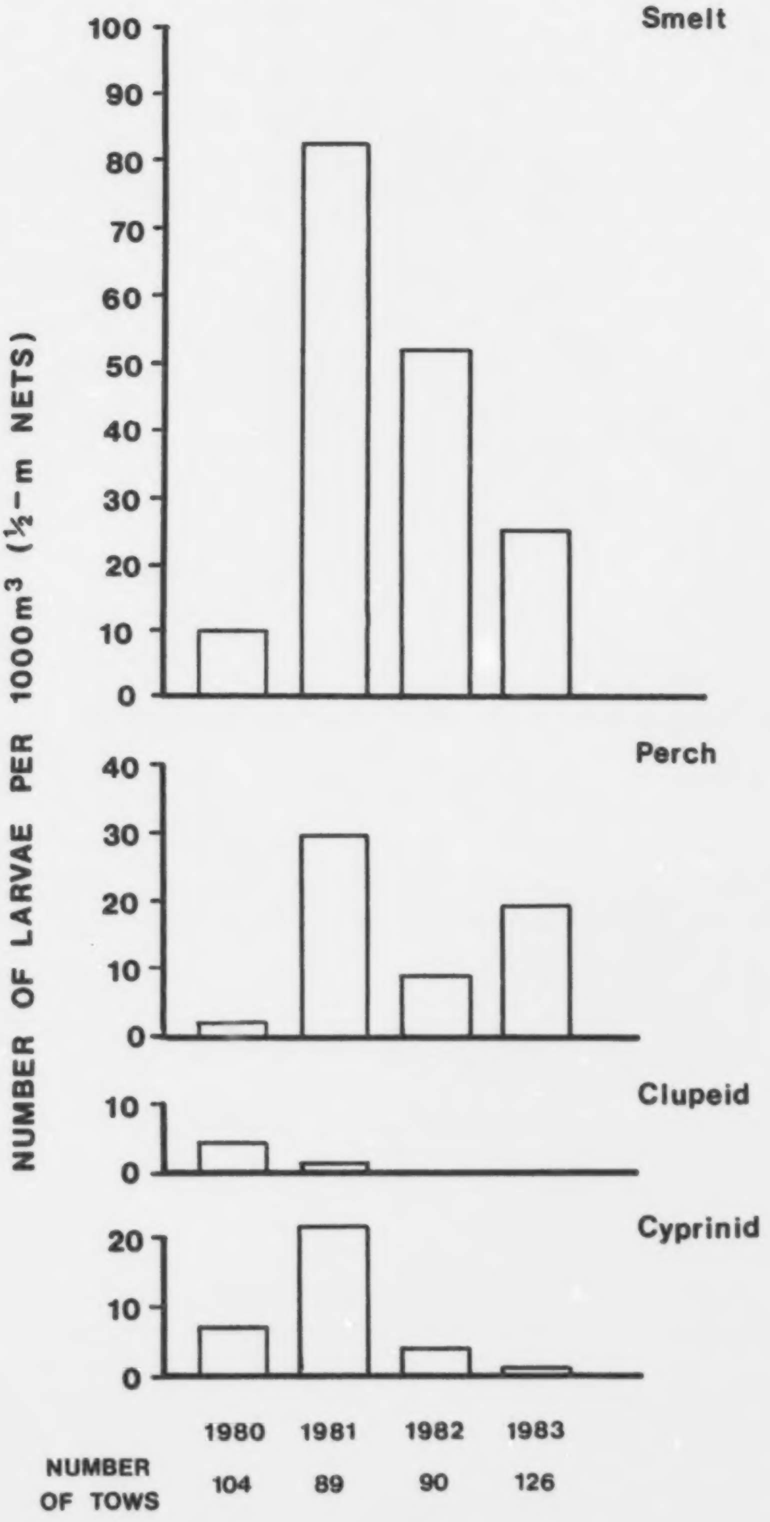
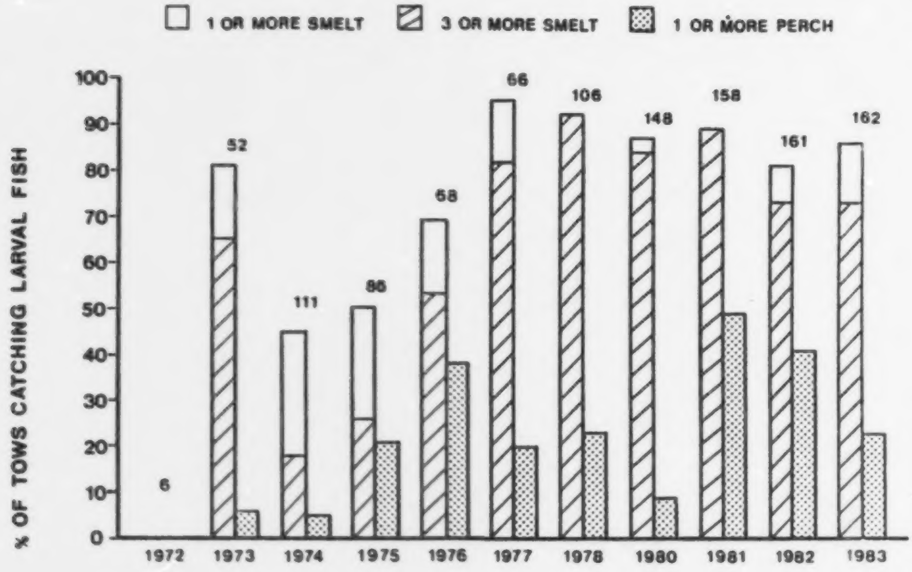


Figure 3.1-11. Numbers of larval fish per 1000 m³ of lake water caught in ½-m plankton nets offshore of Centre Creek in 1980 to 1983 (early May to late August).



| Source of Variation | df | Chi-square ($\chi^2$) statistics by species and response category (= 0 vs > 0 and ≤ 2 vs > 2).<br>Smelt (= 0 vs > 0) | | Smelt (≤ 2 vs > 2) | | Yellow Perch (= 0 vs > 0) | |
|---|---|---|---|---|---|---|---|
| | | $\chi^2$ | P | $\chi^2$ | P | $\chi^2$ | P |
| Year | 10 | 145.3 | 0.0001 | 225.1 | 0.0001 | 110.9 | 0.0001 |

Figure 3.1-12. Results of Logit analysis testing the significance of year on catches of smelt and yellow perch larvae in metre nets during regular monitoring at Nanticoke, 1972-1983 (late May to late June; day and night, and midwater and bottom tows). Values above histogram bars are the No. of tows sampled.

## 3.2 ADULT FISH

### 3.2.1 Trapnet Monitoring Program

#### Introduction

Trap nets operated by the Nanticoke Fish Study (MNR) were the principal gear used to study the abundance and distribution patterns of adult fish in Long Point Bay in relation to industrial activities at Nanticoke. Preliminary analyses of trapnet data to 1978 are presented in annual reports (Kelso 1972, 1973a, Teleki 1973, 1976, Teleki *et al*. 1977), data summaries (Dani and Lockhart 1980, Hamley and Howley 1981, Witzel 1982, 1985b), and a statistical methods report (Howley 1980b).

This report summarizes trapnet catches at Nanticoke from 1971 to 1983. Statistical analyses were applied to a subset of these data in which sampling design was consistent (1975-1983). In addition, supplementary studies were undertaken to examine environmental variables influencing total catch and catches of the major species for the period 1980-1983.

#### Methods

Trapnet sampling at Nanticoke largely consisted of two long-term surveys. The longest was operated from 1971 to 1983 using nets with 8-ft (2.4-m) to 12-ft (3.7-m) cribs. In that survey the general abundance and distribution of fish in the offshore waters from Kitchen Point to Miller Point were examined. In a second survey, initiated in 1980, two or three 6-ft (1.8-m) nets were fished within the nearshore waters of Centre Creek's outfall to monitor more closely (than was possible through the long-term survey with 8- and 10-ft trap nets), the fish community in the vicinity of Stelco's discharge. The objective of the Centre Creek trapnet program (1980-1983) was to provide a data base of preoperational conditions (relative abundance, taxonomic composition) in the waters most likely to be influenced by chemical discharge, for comparison to future conditions when Stelco's production is expected to approach design capacity. In this report, the above described surveys are referred to as the Nanticoke and Centre Creek studies (or trap nets), respectively.

Other trapnet sampling not discussed here include the Stelco dock study (1975-1976) and monitoring west of Nanticoke from Port Ryerse to Bluff Bar (1971-1974). Results of these surveys are documented elsewhere (Chamberlain 1976, 1979, Hamley and Howley 1981, 1985).

### (i) Gear

Trap nets used in our studies were a regular type used in commercial fisheries. Commercial trapnet operations in Lake Erie have been described by Langlois (1954). Trap nets operated in our program were fabricated from black polypropylene twine. Those fished at Centre Creek (1980-83) had 6-ft (1.8-m) cribs and 125-ft (38-m) leads; mesh size was 1.5 inches (38 mm) in the crib and 2.25 inches (57 mm) in the lead. With the exception of the Oneida trap net (10-ft crib) all Nanticoke nets had 8-ft (2.4 m) cribs. Mesh size of the cribs in all Nanticoke nets was 2 inches, except the East Brown's Pt. net, which was 2.25 inches. Details of crib size, mesh size, and lead length of trap nets operated at Nanticoke and Centre Creek since 1975 are summarized in Table 3.2.1-1. Specifications of trap nets sampled before 1975 can be found in Dani and Lockhart (1980).

Nanticoke trap nets were serviced by a 12.8-m trapnet boat (David-M) and the Centre Creek nets by one of two outboard boats (7.3-m Harley-P and 6.4-m Johnny-B).

### (ii) Sampling Locations and Design

Two grid systems were used to designate trapnet locations: Kelso's system (Kelso 1973a) was applied in 1971-1972 trap netting; thereafter, Teleki's system (Teleki 1973) was followed. In 1971-1974, up to 25 sites were sampled at Nanticoke. Beginning in 1975, sampling was restricted to six standard locations until May 1981, and at only five locations thereafter (Selkirk discontinued). In 1982 and 1983 a second net (East Plume) was set in the thermal plume of the Nanticoke Generating Station (NTGS) to provide more data on fish abundance and species composition in the plume waters.

From 1971 to 1973, trap nets were fished in pairs along north-south grid lines (meridians of longitude), with one net set in shallow (3-6 m) the other in deep (5-12 m) water. Vertical grid lines were spaced at 1.6-km intervals. Each pair of nets were fished at a location for a few days then moved to another set of sites along an adjacent vertical grid line. After 1973, trap nets were fished one to a site for an entire season; sampling locations corresponded to the shallower of the paired sets from the earlier years. Nets were lifted twice weekly and washed once or more during the summer.

Trapnet sites sampled near standard locations in the earlier years (1971-1974) were pooled to achieve greater sample size. The sample sites that we combined before 1975 and those designated as standard locations (Figure 3.2.1-1) are described in Table 3.2.1-2.

Net (crib) sizes were different from year to year and location to location (Table 3.2.1-3). From 1971 to 1973, 8-ft nets were fished at the shallow (3-6 m) locations and 12-ft nets at the deep (5-12 m) locations. In 1974 8-, 10-, and 12-ft nets were used. In 1975 and later, 8-ft nets were fished at all Nanticoke locations except Oneida (10-ft net).

At Centre Creek, two 6-ft trap nets were fished about 100 m offshore, and approximately 100 m apart. In 1982 a third net (6-ft crib) was fished between the two standard nets directly in front of the mouth of Centre Creek to capture fish entering the creek during spawning. Nets were sampled twice weekly, usually on the same days as Nanticoke nets.

In most years the trap nets were fished from late April to late October. The sampling period was divided into four "seasons" for purposes of data summary and statistical analyses. Dates were grouped as follows to achieve sampling periods (seasons) with adequate and similar numbers of lifts: spring (April 1 - May 31), early summer (June 1 - July 19), late summer (July 20 - August 31), and fall (September 1 - October 31).

All fish captured in trap nets were counted and most were released alive, some with numbered anchor tags (spaghetti type) attached to their backs for mark-recapture studies (see Section 3.2.5).

Subsamples of fish were returned to the laboratory for measurements of fork and total length (to nearest mm) and weight (to nearest g), and determination of sex, maturity, and age (by interpretation of scale markings).

### (iii) Statistical Analyses of Catch Data

Raw and log-transformed catches (counts) of selected species were analyzed for effects of year, season, and location. Data prior to 1975 were excluded from all analyses because of methodological inconsistencies with the later years (1975-1983). Data from Nanticoke studies (1975-1983) were analyzed separately from Centre Creek studies (1980-1983); however, the same statistical procedures were applied to both data groups.

Five locations at Nanticoke (Peacock Point, Oneida, West Plume, East Brown's Point, West Brown's Point) and two at Centre Creek (East and West Centre Creek) were sampled consistently within and among years. Only these locations were included in the main analyses. Trap netting was curtailed in 1979; therefore, no data are available for this period.

Preliminary statistical analyses of trapnet data to 1978 were performed by Howley (1980b). A condition of the trapnet data found in Howley's (op. cit.) and in the present analyses was that most species were caught too infrequently for their counts to be examined by conventional parametric procedures. Only the most common species, rock bass and yellow perch, were caught frequently enough to validate an ANOVA.

Howley's (1980b) treatment of rock bass and yellow perch catches was to normalize and standardize the data then apply an ANCOVA with net size and soaktime as covariates. However, on advice from an expert bio-statistician (Hines 1982), we applied a simpler and more conventional transformation. An examination of the residuals in a subset of the trapnet data showed that a logarithmic transformation ($\log_{10}$ x + 1) achieved roughly constant variance and normality. Although soak time varied somewhat with year, season, and location (Tables 3.2.1-4 to -6), its effect on catches of yellow perch and rock bass was not significant in most combinations of location with season (see table below) for soak times of 10 days or less (65% of the soak intervals between trapnet lifts at Nanticoke and 78% at Centre Creek were three to five days). Thus, insufficient evidence was found to necessitate treating soak time as a covariate in an ANCOVA. Although the Oneida trap net (10-ft crib) caught larger yellow perch and rock bass than did the 8-ft Nanticoke trap nets, the differences (which were significant for combined ages but not for specific age groups) were not considered to be great enough to warrant treating crib size as a covariate (see table below)

Instead a three-factor ANOVA was applied: specifically, because of unequal sample sizes, the GLM procedure in SAS (SAS Inst. Inc.) with type III sums of squares (SS) was used.

In the 8 years (1975-1983) of standardized trapnetting at Nanticoke some 1,546 lifts were examined; because of the large error degrees of freedom (1,386) and naturally high variability among catches, all the F-ratios in the three-factorial models were significant (P = 0.0001).

| | | | *Correlations (r) of $\log_{10} x + 1$ catch with soak interval (days) | |
|---|---|---|---|---|
| Location | Season** | N | Yellow perch | Rock bass |
| Peacock Point | Spring | 61 | 0.005 | -0.134 |
| | Summer | 140 | -0.049 | -0.155 |
| | Fall | 72 | 0.101 | 0.069 |
| Oneida | Spring | 68 | 0.095 | $0.294^{+}$ |
| | Summer | 165 | 0.084 | 0.028 |
| | Fall | 83 | 0.208 | $0.229^{+}$ |
| West Plume | Spring | 67 | -0.047 | 0.169 |
| | Summer | 161 | 0.071 | 0.017 |
| | Fall | 79 | 0.164 | $0.275^{+}$ |
| East Brown's Point | Spring | 70 | 0.173 | 0.099 |
| | Summer | 161 | 0.024 | 0.053 |
| | Fall | 82 | $0.224^{+}$ | 0.169 |
| West Brown's Point | Spring | 70 | 0.233 | 0.235 |
| | Summer | 154 | $0.177^{+}$ | 0.121 |
| | Fall | 76 | 0.011 | -0.064 |

* Data includes soak intervals of 10 days or less, 1975-1983.

** pring = April - May; Summer = June - August; Fall = September - October.

+ Correlation coefficient significant at P = 0.05.

Consequently, all the main effects (year, season, location) and only the statistically significant ($P < 0.05$) second order interactions were examined in detail. A detailed analysis consisted of developing and inspecting a series of histograms of the least squares mean (LS Mean) catch for each effect considered (LS Means are an adjustment for unequal sample size). Probability tables of LS Means produced by the GLM procedure (SAS Inst. Inc.) were consulted to determine if point comparisons were significantly different ($P < 0.05$).

As noted earlier, catch frequencies of most species contained too high proportions of zeros to be transformed into approximately normal distributions. Of the 30 plus species caught in trap nets, nine species or pairs of species were analysed by Logit analysis, a non-parametric procedure. Logit analysis was chosen over a possible alternative, log-linear analysis (Bishop et al. 1975), for the same reasons described previously in the statistical analysis of larval fish data (Section 3.1).

For the infrequently captured species or "pair of species", their raw catches were categorized as either present (catch > 0) or absent (catch = 0). Pairs of taxonomically and ecologically similar species were combined to achieve the sample sizes required to validate logit analyses. The three pairs of species examined were black and white crappie (crappie), brown and yellow bullhead (bullhead), and bluegill and pumpkinseed (sunfish). Season in all models, and season and location in some models were pooled to achieve greater sample size and to minimize the number of empty cells (cells in which a species was absent from all lifts). Significant effects were examined by plotting the observed catch response (% of lifts catching fish) for the significant effect.

### (iv) Age and Size Composition

Scale samples from yellow perch, smallmouth bass, rock bass and white bass were collected annually for aging. However, determination of age composition from aged fish in trapnet catches before 1980 was hampered by small sample sizes in most years and non-random sampling in some years (1978-1978) (see Section 4.3). Fork lengths of most fish captured by trap nets were measured from 1974 to 1978 and this data, in combination with the small subsamples of aged fish from each year, enabled estimation of age composition of the catch for this period from age-length keys developed for each year's catch (Ricker 1975). Backcalculated fork lengths-at-last-annulus (length at the end of the last full year of life) for individual fish were determined to compensate for apparent differences in growth resulting from different capture times. Using these lengths, the proportion of each age class within the 40-149, 150-204, 205-259, and > 60-mm fork length intervals was then used to convert the length distribution of spring trapnet catches to age.

Age compositions of the 1980-1983 catches were determined entirely from aged fish. However, comparisons of age composition across all years (1974-1983) were possible only for spring (April and May) trapnet catches pooled over all locations. More detailed examinations of differences in age composition across season, locations or sexes were possible for only the 1980-1983 study period because large, representative subsamples of the catches were aged in those years (see Section 4.3). The age composition of each species for the 1980-1983 catches was calculated and summarized across seasons and crib size in tabular or graphic form. No statistical analyses were performed on the age composition data series.

Statistical analyses comparing mean lengths (all ages) or mean lengths at age across locations were performed to determine if differences in mesh size and/or crib size of trap nets induced differential selectivity among locations. As the same net was set at the same location each year, gear selectivity may have caused some of the highly significant differences in catch among locations. Moreover, because significant growth occurred over most seasons for several of the important species, we examined the possibility that gear selectivity contributed to differential seasonal recruitment patterns among trapnet locations. Where sample sizes permitted, seasonal analyses and comparisons of age and length composition were performed across all four trapnet seasons defined previously; however, in some cases, small sample sizes in the two summer seasons forced us to collapse early and late summer into one season (summer).

Trapnet selectivity was examined in several ways but only from the 1980-1983 catches of yellow perch, rock bass, and white bass. The first set of analyses considered trapnet catches grouped according to the three major trapnet crib sizes (6-, 8-, and 10-ft cribs). In these analyses a series of one-way ANOVA's were carried out comparing seasonal mean fork lengths of the three species across crib size. Where sample sizes were sufficient, additional ANOVA's were performed comparing seasonal mean fork lengths-at-age across crib size.

Several components among the Nanticoke trap nets differed in mesh size (Table 3.2.1-1). Mesh size of the crib was the same (2.0 in.) among Nanticoke trap nets except for the 8-ft net fished at East Brown's Pt. (2.25 in.). Mesh size of the funnel, heart, and wings was also larger in the East Brown's Pt. (2.25 in.) and East Plume (2.5 in.) trap nets than in the nets (2.0 in.) fished at the four remaining standard locations. Mesh size of the lead in the 10-ft net fished at Oneida (4.75 in.) was twice as large as the other Nanticoke nets (2.0 in.). Because of these mesh-size differences, an additional series of

ANOVA's were performed to test for differences in seasonal mean length and mean backcalculated lengths-at-age of yellow perch and rock bass across the five standard Nanticoke trap nets (Peacock Pt., Oneida, West Plume, East Brown's Pt. and West Brown's Pt.) using only the 1981-1983 catch data. A similar set of ANOVA's were performed comparing mean lengths (pooled ages and seasons) and backcalculated lengths-at-age of fish captured by the West Plume net to those in the East Plume net (1982-1983).

We emphasize that the above tests for gear selectivity come completely from unplanned and uncontrolled experiments; at best the results of these tests can be expected to provide only "indications" of selectivity, and at a fairly gross level. The many complicating effects relating to differences in environment or fish behavior among the various trapnet locations could not be examined in relation to the effects of mesh size.

### (v) Environmental Effects on Catch

Environmental data were obtained for periods corresponding to the soak intervals of trap nets fished from 1980 to 1983. Meteorological data were provided by the Ontario Ministry of the Environment measured at a 10-m tower in Jarvis and the Environment Canada weather station in Simcoe, Ontario. Daily readings of the following variables were recorded: mean (nearest 0.1 km/h) and maximum (nearest km/h) wind speed, most frequent (modal) wind direction, and wind direction at maximum wind speed.

Environmental variables considered that pertain to operations of the NTGS were mean intake (lake) and outfall temperatures (nearest °C), mean discharge flow (nearest $m^3/s$), and mean station power production (nearest MW); these were measured daily by Ontario Hydro. In addition, water temperatures (nearest 0.1°C) at the surface, middle, and bottom of the water column were measured by the trapnet crew on lift days.

Wind direction data were coded as follows: N=1, NE=2, E=4, SE=6, S=8, SW=7, W=5, NW=3. Higher values were assigned to onshore winds (from a southerly direction) and winds from a westerly direction because these types, in general, generate a stronger wave effect at Nanticoke (wave intensity) than do offshore or easterly winds. Indices of wave intensity were calculated by taking the product of wind direction and wind speed: mean wave index = modal wind direction x mean wind speed; maximum wave index = wind direction at maximum wind speed x maximum wind speed. Higher wave intensities resulted from onshore compared to offshore winds of the same speed.

The amount of association between $\log_{10}$ catches of selected species and environmental variables was determined by Pearson product-moment correlation analysis at a significance level of 5% or less ($P \leq 0.05$). Correlation coefficients were calculated by season for grouped Centre Creek trap nets and grouped Nanticoke trap nets with years (1980-1983) pooled. Stepwise multiple regressions (maximum $R^2$ improvement) were applied to derive the best equations for predicting total catch and catches of selected species in trap nets, and to examine the amount of variation in catch due to one or more environmental effects. Transformations of environmental variables were deemed unnecessary except in the case of mean and maximum wind speed, which were logged (base 10) to make the variance independent of the mean. SAS (SAS Inst. Inc.) programs were used for all correlations and regressions.

## Results

Rock bass and yellow perch were by far the most frequently captured fish in Nanticoke (Table 3.2.1-7) and Centre Creek (Table 3.2.1-8) trap nets. Combined, rock bass and yellow perch comprised more than 60% of the total catch in all years except before 1974 when freshwater drum was the dominant species (29-45% of total yearly catch).

Only about half of the 30 or so other species caught since 1974 were captured each year (Table 3.2.1-7). Trap nets averaged 5 or fewer fish species per lift, but individual lifts with 10 to 15 species were not uncommon (Table 3.2.1-9). Even the most abundant of the incidental species or species pairs (smallmouth bass, white bass, white sucker, sunfish, crappie, gizzard shad, bullhead, and quillback) were absent from 70% of all trapnet lifts (Tables 3.2.1-10 and -11. In comparison, rock bass and yellow perch were present in 80% or more of all lifts. Freshwater drum were taken in 43% of lifts at Nanticoke, but in only 22% at Centre Creek.

White perch were first observed in trapnet catches (Nanticoke and Centre Creek) in 1981 (Tables 3.2.1-7 and -8). Two years later (1983), their relative abundance increased approximately five fold. White bass have exhibited sporadic increases since 1971, most recently in 1981. The number of gizzard shad captured in trap nets increased sharply in 1983.

Variability among catches of even the most common species and total catch (all fish) was high (Tables 3.2.1-12 and -13). The standard deviations were typically as large or larger than their means (mean No./lift). In the ANOVA's of Nanticoke and Centre Creek data, the effects of year, season, and location (including interaction terms) accounted for 60% or more of the total variability (expressed as a percentage of explained SS/total SS) in log-transformed catches of yellow perch and rock bass (Tables 3.2.1-14 and -15).

### (i) Location

The effect of location (Nanticoke trap nets) on catch was statistically significant (P = 0.0001) in the ANOVA of yellow perch and rock bass (Table 3.2.1-14) and in the Logit analysis of freshwater drum, smallmouth bass, white sucker, crappie, white bass, and quillback (Table 3.2.1-16). No significant effect on catch due to location was detected by ANOVA or Logit analyses for any species at Centre Creek (Table 3.2.1-14 and -16). The most notable, location difference was the significantly higher numbers of fish (Table 3.2.1-14), particularly yellow perch and rock bass, captured at the West Plume (NGS Plume) net (Figures 3.2.1-2 and -3). Total catch and catches of yellow perch and rock bass were lowest in the East Brown's Point net (Table 3.2.1-17). Averaged over years (1975 - 1983) and seasons (April - October), more species of fish were caught per lift at the West Plume (mean = 5.5) than at any other location (mean = 2.8 - 4.9), including the Centre Creek nets (mean = 3.8 - 4.0) (Table 3.2.1-9). East and West Brown's Point averaged the fewest number of species per lift (2.9 and 2.8, respectively).

In 1982 and 1983, two trap nets were fished in the outfall of the Nanticoke Generating Station. One net (standard net sampled in 1974-1983) was fished in the west perimeter of the plume (West Plume) approximately 250 m from the discharge channel, the other net was fished in the east perimeter (East Plume) at a similar distance from the discharge channel. The distance between the two plume nets was about 300 m. ANOVA showed that catches of yellow perch and rock bass were significantly (P = 0.0001) higher in the west than east net (Table 3.2.1-15, Figure 3.2.1-16).

### (ii) Season

Catches of yellow perch, rock bass, and freshwater drum were highest in the spring, whereas catches of sunfish, crappie, bullhead, gizzard shad, quillback, and white bass were generally highest in late summer or fall (Table 3.2.1-17 and -18). Differences in catch due to season were significant (P = 0.0001) for both yellow perch and rock bass (Table 3.2.1-14). Although not examined statistically the effects of season on catch was also apparent in most of the incidental species (Table 3.2.1-17 and -18).

Catches of yellow perch and rock bass declined with season at Centre Creek as did catches of rock bass at Nanticoke (Figures 3.2.1-3 and -4). In the Nanticoke nets, high spring catches of yellow perch were followed in the summer by lowest or comparatively low catches (Figure 3.2.1-2).

### (iii) Year

Year-to-year variations in catch of the two most common species (to 3-fold) and in the less frequently taken species (to 16-fold) were considerable (Figures 3.2.1-2 to -9) and highly significant (Tables 3.2.1-14 to -16). The average catch/lift of yellow perch and rock bass captured in Nanticoke trap nets (pooled locations) tended to peak in 1981 and has declined thereafter (Figures 3.2.1-2 and -3). In the Centre Creek nets, however, catches of these species increased significantly in 1982 and/or 1983 (Figure 3.2.1-4). The number of trapnet lifts which caught samllmouth bass, white sucker, and white bass was higher at some Nanticoke locations (primarily Peacock Pt. and West Plume) in the initial years of the operational period (1980 and/or 1981) than during the commissioning period (1974-1979), but there were decreases in abundance of these and other incidental species (crappie, bullhead) through the operational period. In contrast, the number of lifts that caught fish at Centre Creek tended to increase during the operational period for most of the incidental species (Figures 3.2.1-8 to -9). A substantial increase in the mean number of fish species captured at Centre Creek was observed in 1982 and 1983 (1981 mean = 2.3; 1983 mean = 5.4) (Table 3.2.1-9).

The LS Mean number of yellow perch caught in the two plume nets was significantly ($P < 0.001$) higher in 1982 than in 1983 (Table 3.2.1-15, Figure 3.2.1-16). Catches of rock bass in the plume were similar in 1982 and 1983.

### (iv) Interactions

Interaction of location with year was significant (P = 0.0001) in all ANOVA and Logit models and accounted for more of the explained variation in catch than did any other second or third order interaction term (Tables 3.2.1-14 to -16). A graphical examination of the year by location effect in yellow perch (Figure 3.2.1-10 and -12), rock bass catches (Figures 3.2.1-11 and -12), and in the catches of incidental species (Figures 3.2.1-5, -6, and -8) showed that the relative distribution of catches among locations was not consistent from one year to the next. For example, yellow perch densities (LS Mean No. per lift) were highest at West Brown's Point in 1975, lowest there in the following year, and highest again in 1978 and 1980 (Figure 3.2.1-10). The highest or second highest catch of rock bass (LS Mean No./lift) occurred at each of the five Nanticoke trapnet locations in at least one year from 1975 to 1983 (Figure 3.2.1-11). At Centre Creek, rock bass catches were highest in the west net in 1980 and 1983 and lowest at that location in 1981 and 1982 (Figure 3.2.1-12). Although more yellow perch and rock bass were taken at the NTGS Plume than elsewhere (Figures 3.2.1-2 and -3), the adjusted group means (LS Means) show that only in half of the eight survey years were yellow perch densities actually highest at the plume (Figure 3.2.1-10); densities of rock bass were highest in the plume in five of the survey years (Figure 3.2.1-11). However, for both species, catches were consistently highest at the plume during the operational period.

Other significant (P = 0.0001) second order interactions included a year by season effect on catches of rock bass and yellow perch in

Nanticoke (Figure 3.2.1-14), and Centre Creek (Figure 3.2.1-13) nets, and a location by season effect on the same species in Nanticoke nets (Figure 3.2.1-15). Three-way interactions of year, season and location were also significant in the ANOVA's.

The most significant interaction observed in the ANOVA's of fish catch in the two plume nets (1982-1983) was that of year with season (P = 0.0001) for rock bass and season with location (P = 0.0001) for yellow perch (Figure 3.2.1-16). These effects accounted for <7% of the total variation in catches of these species (Table 3.2.1-15).

### (v) Residual Variation

Standard deviations of mean yellow perch and rock bass catches within subgroups of the three design factors (combinations of year, season and location) were only half as large (Table 3.2.1-12) as those for the entire sampled population (No. lifts of Nanticoke trapnets = 1,546) with years, seasons and locations combined (mean < SD No. of yellow perch per lift = 10.2 < 19.5; mean < SD No. of rock bass per lift = 11.8 < 24.2). This residual or unexplained variation accounted for 35 - 41% of the total sums of squares in the ANOVA'S (Table 3.2.2-14). Several factors likely contributed to this variation. We investigated the possibility that day-to-day weather conditions influenced fish movements and their catchability. The results of these studies are summarized in section vii of the Results.

### (vi) Age and Size Composition

Some evidence of selectivity against certain size or age classes of fish was detected in the trapnet catches of selected species. The 6-

ft nets (1.5-in mesh cribs) captured significantly smaller yellow perch, rock bass and white bass than did the 8- or 10-ft nets at Nanticoke (2.0 - 2.5 in mesh cribs) (Table 3.2.1-19, Figure 3.2.1-17). In addition, the 10-ft net (4.75-in mesh lead) at Oneida captured slightly, but significantly larger yellow perch and rock bass than did the 8-ft nets. The effect of trapnet crib size was evident even on the size-at-age of yellow perch and rock bass captured in the spring; significantly smaller fish at age were captured in the 6-ft nets than in the larger nets (Table 3.2.1-20). Differences in length-at-age between 8- and 10-ft nets generally were not significant. Small sample sizes precluded similar comparisons of size-at-age for other species.

Analyses of mean fork lengths (pooled ages) and backcalculated lengths-at-age across the five standard Nanticoke trap nets revealed that the mean lengths and mean lengths-at-age (most prominent age classes only) of yellow perch and rock bass differed significantly among the nets (Table 3.2.1-21). While there was some tendency for the East Brown's Pt. and, in particular, the Oneida net to capture larger yellow perch, the trends in relative fish size per net was not consistent across the three years examined (note the significant year x location interactions) (Figure 3.2.1-18). The trends in rock bass catches were even less consistent; consequently, the differences in size or size-at-age do not appear to be strongly related to differences in mesh size among the various components of the five Nanticoke trap nets. Similar examinations of mean fork length (ages and seasons pooled) and mean length-at-age for selected fish species across the East and West Plume nets (1982-1983) produced significant differences between the nets (Tables 3.2.1-22 and -23) and, where significance occurred, the fish were invariably larger in the East Plume net.

While slight differences in mean fish length were detected among the various Nanticoke trap nets, the length differences were usually small. The only clear evidence of selectivity was among the three trapnet crib sizes (6-, 8- and 10-ft). In these comparisons, differences in mean fork length were reflected also by differences in age composition. In general, the youngest age classes of yellow perch and rock bass were more important in the 6-ft nets than in the 8- or 10-ft nets, whereas the opposite was true for the oldest age classes (Table 3.2.1-24). Moreover, older age classes of yellow perch and rock bass were even more prominent in the 10-ft net than they were in the pooled catches from the 8-ft nets. The age composition of white bass catches exhibited a similar pattern; age 0 white bass were more prevalent in the 6-ft nets (particularly in fall) than they were in the larger crib sizes (Table 3.2.1-25). Too few smallmouth bass were captured at Centre Creek in 1980 and 1981 to enable comparisons between 6-ft and larger nets, and the age composition of the 1982 and 1983 catches conflicted (in 1982, the younger age classes were far more important in catches of the 8- and 10-ft trap nets, probably due to particularly large catches of age II bass at the plume) (Table 3.2.1-25).

Yellow perch did not become strongly vulnerable to the Nanticoke nets until the fall of their second year. While age II perch were much more important in Centre Creek (6-ft net) catches in all seasons than in the Nanticoke catches (Tables 3.2.1-26 and -27), there was a similar tendency for this age class to become more vulnerable to Centre Creek nets through the seasons (Figure 3.2.1-19). Age II perch appeared to recruit into the Centre Creek nets earlier and more rapidly than they did at the Nanticoke locations, and the faster growing females were usually more vulnerable than males in all net sizes at this age in the spring (Figure 3.2.1-20).

Age III perch remained important in the Nanticoke trapnet catches through all seasons, but their importance usually declined between late summer and fall (at which time age II fish rapidly recruited into the nets). In Centre Creek nets, the percent composition of age III perch declined steadily through all seasons. In general, the seasonal progression of the two dominant age classes (II and III) of perch in all trapnet crib sizes was inversely related except in the fall when age class dominance was usually determined by the relative strengths of the individual year classes (Figure 3.2.1-19). This effect probably was magnified by the progressive removal of age III perch from the population by commercial gillnetters in Long Point Bay. Commercial harvests of perch were comprised mostly of age III fish. Similar to our trapnet catches, age II perch did not become important in commercial gillnet catches until fall (Table 3.2.1-28). Unless there was a particularly strong year class, age V and older perch were not abundant in either the trapnet or commercial gillnet catches.

The recruitment pattern of rock bass into trap nets was less clear, but indicates that this species first became vulnerable to trap nets at age III in late summer or fall. Age III and IV rock bass typically were less important in spring catches than in the later seasons (Tables 3.2.1-29 and -30; Figure 3.2.1-21). Within the age classes examined, no clear differences in recruitment between males and females was noted (Figure 3.2.1-22). Age V and older rock bass typically were most important in spring catches, and declined somewhat in percent composition through the summer and fall as the younger age classes recruited into the nets. In general, Centre Creek nets captured a higher percentage of age III and IV rock bass than did the Nanticoke nets, whereas age V and older rock bass were somewhat more important in the Nanticoke nets (Figure 3.2.1-21).

The age composition of smallmouth bass catches in our trap nets was highly variable and seasonal trends were unclear due to small sample sizes. While smallmouth bass did not appear to become strongly vulnerable to the Nanticoke nets until age III in most years, age II fish (and even age I fish in the fall) were significant in the catches when a particularly strong year class was produced (Table 3.2.1-25). Depending on year class strengths, the dominant age class of smallmouth bass was age III or older (Table 3.2.1-25). Small sample sizes of smallmouth bass collected from Centre Creek precluded comparisons of age composition among trap sizes. Age I white bass were most often the dominant age class in trapnet catches at both Centre Creek and Nanticoke (the strong 1980 year class was important in the catches as early as age 0) (Table 3.2.1-25).

Inspection of annual age composition data from the Nanticoke trap nets revealed that strong year classes of yellow perch, rock bass and smallmouth bass were produced in 1971 and 1977 (Figures 3.2.1-23 to -25). In addition, the 1980 year class of smallmouth bass and white bass appeared to be strong (Figures 3.2.1-25 and -26). Strong year classes of rock bass (and smallmouth bass in the earlier years) persisted in significant numbers for many years, whereas strong year classes of yellow perch (and smallmouth bass in the later years) declined quickly. Rapid declines of strong year classes may reflect commercial and/or sport harvests of these species (significant harvests of smallmouth bass in the Nanticoke area have occurred only recently with the development of a growing sport fishery in the area). Neither sport nor commercial fishermen target on rock bass and the species is harvested only incidentally with catches of target species (yellow perch, white bass and smallmouth bass).

### (vii) Environmental Effects

Some of the environmental variables we related to trapnet catches from 1980-1983 showed a distinct seasonal relationship, whereas others showed very little or no pattern across seasons (Figure 3.2.1-27). Water temperature demonstrated the most consistent trend from year to year. Mean lake temperature was typically 7-10°C in the early part of May when trap nets were first sampled. Lake water warmed rapidly through June and July, reaching a maximum of approximately 24°C in late August (Table 3.2.1-31). Thereafter lake temperatures cooled rapidly to approximately 10.0°C in late October when trapnet fishing was concluded. Water temperatures were similar among trapnet locations except at the two plume locations which averaged a degree Celcius or so warmer in the spring and fall than the other net sites (Table 3.2.1-31).

Winds were usually the calmest in mid-summer and onshore more often than offshore from about June through to September (Figure 3.2.1-28).

Wind speeds averaged higher throughout all months in 1980 than in 1981-1983 (Figure 3.2.1-27). Wind direction and secchi transparency demonstrated little seasonal trend over the four years we observed them. However, secchi disc transparencies were, on average, higher at the offshore net sites (Nanticoke) than at the sites near shore (Centre Creek) (Table 3.2.1-31). Secchi transparency was negatively correlated ($P < 0.05$) with mean wind speed at the inshore (Centre Creek) and offshore (Nanticoke) trapnet locations in all seasons except late summer.

Information pertaining to bottom sediments and vegetation patterns in the Nanticoke area was derived from the studies of other researchers and our own observations. The nearshore area of Nanticoke is predominately rock (Dunford 1980, Heathcote 1981). Sediments overlying bedrock decrease in texture and increase in depth with distance offshore (Thomas _et al_. 1976). Coarse sediments along the north shore of Long Point Bay change to extensive sand and mud flats that extend throughout the central, western, and southern portions of the bay. Our observations of sediment composition at specific trapnet locations also indicate a substantial rock component, but we found sandy-mud to be the predominate material (Table 3.2.1-32). Bedrock was exposed in some locations (eg. Centre Creek) and covered by a thick mud in others (eg. NTGS plume).

Submergent macrophytes were almost non-existent in the Nanticoke area (Walker and Johnson 1973) (Table 3.2.1-32). The predominate vegetation type found near shore was filamentous algae, probably

Cladophora spp. (Walker and Johnson 1973, Dunford 1980). Its growth at the trapnet locations was short and relatively sparse (Table 3.2.1-32).

The strength and direction of the linear relationship between trapnet catch and specific environmental variables was not consistent among seasons or between Nanticoke and Centre creek trap nets (Tables 3.2.1-33 and -34). Water temperature correlated significantly with catches of yellow perch but not rock bass in Nanticoke nets (Table 3.2.1-33). The effect of temperature on yellow perch catches was negative but significantly so only in the spring and early summer. In Centre Creek nets, reduced catches of yellow perch and rock bass also were associated with increased temperatures during the summer months; but during the fall, reduced catches of yellow perch were associated with reduced temperatures (Table 3.2.1-34). Increased wind speeds were associated with increased catches of yellow perch and rock bass in all seasons in Nanticoke trap nets, but the effect was significant only for perch in early summer and fall. Conversely, increased wind speeds tended to be associated with decreased catches of yellow perch and rock bass in Centre Creek in most seasons (except in late summer when perch catches varied directly with wind speed).

Wind direction had no effect ($P > 0.05$) on fish catches in Nanticoke nets and only a minor one on catches in Centre Creek nets (Tables 3.2.1-33 and -34). Onshore winds were positively correlated ($P < 0.05$) with yellow perch and rock bass catches in late summer. Wave activity index - a function of wind speed and direction - was not associated

($P > 0.05$) with fish catches in the Nanticoke trap nets, but in the Centre Creek nets some evidence of increased catch with wave activity was apparent in late summer.

The relationship between secchi disk transparency and fish catch in Nanticoke trap nets (Table 3.2.1-33) was opposite to that observed in the Centre Creek nets (Table 3.2.1-34). In the latter group, increased catches of primarily yellow perch coincided with increased transparency, but in the deeper set trap nets (Nanticoke nets), reduced numbers of fish were caught with increased transparency.

The four environmental variables, which best correlated with trapnet catches were fit into a multiple regression model. Those selected were water temperature, secchi depth, maximum wind speed, and wind direction at maximum wind speed. The best multiple regression equation of one to four independent variables was selected by a forward stepwise procedure (maximum $R^2$ improvement). Independent variables explaining <1% of the variation in log-10 catch were excluded from linear models.

No single variable consistently explained most of the variation in trapnet catches over the four previously defined trapnet seasons (Table 3.2.1-35). For example, water temperature explained <1% of the variability in total catch by Nanticoke trap nets in the spring (Equation 1), 12% in early summer (Equation 4), <1% in late summer (Equation 7), and 5% in fall (Equation 10). Contributions of specific environmental variables towards explaining variation in catch was not the same between Centre Creek and Nanticoke trap nets (Table 3.2.1-35). For example, secchi transparency explained 42% of the variation in total fish catch by Nanticoke nets in the spring (Equation 1), but <1% in Centre Creek nets (Equation 13). Nor were variations in catches of yellow perch and rock bass explained equally by specific environmental variables within the Nanticoke or Centre Creek trap nets during a particular season (Table 3.2.1-35). For example, secchi depth explained 21% of the variation in yellow perch catch (Equation 14), but only 4% of the variation in the spring catches of rock bass at Centre Creek (Equation 15).

The inclusion of a second, third or fourth independent variable into regression models improved the multiple correlation coefficient ($R^2$) by as much as 16%, but in some models additional variables contributed little or no information to the $R^2$. About half of the 12 linear models tested were significant ($P < 0.05$; Table 3.2.1-35). The linear models pertaining to Nanticoke trap nets explained more of the variability in catch in spring and early summer than in the other seasons, whereas the models describing Centre Creek trapnet catches were significant predominately in seasons other than in spring.

Possible relationships of environmental variables with fish catch in the two plume nets (east and west) were also examined (Table 3.2.1-36). Discharge water temperature and ambient temperature (near trap nets) were more closely correlated with catches of yellow perch than rock bass. The relationship was mostly negative over the four seasons except in late summer at the East Plume net. Increased catches were associated with increased wind speed and wave activity and to some extent with onshore winds. The relationship of these variables with catch was strongest in the fall and weakest in early summer (Table 3.2.1-36).

Water transparency (secchi transparency) had no apparent effort on catches of yellow perch in the two plume nets, but did show a significant negative relationship with rock bass catch and total catch (Table 3.2.1-36). Increased levels of station discharge flow correlated significantly with increased catches of yellow perch and rock bass in early summer, and with decreased catches of these species in the fall.

## Discussion

Trapnet catches in the littoral zone at Nanticoke were dominated by yellow perch (22-45% of annual total catch) and rock bass (31-46%). These two species plus the 30 or so other species taken in trap nets at Nanticoke range throughout Long Point Bay, although their relative numbers within the fish community undoubtedly varies considerably with habitat from one area to the next. For example, Hamley and Howley (1985) reported much higher concentrations of fish, primarily quillback (approx. 50% of total catch) along the south shore of Long Point Bay than along the north shore near Nanticoke (quillback represented approx. 2% of total catch).

We did not include catch data prior to 1975 in our analyses because of methodological inconsistencies with the later sampling years (1975-1983). The much deeper (3-12 m) sets with net (crib) sizes to 12 ft in 1971 to 1973 is probably why fish catches in those years consisted mostly (29-45% of total catch) of freshwater drum (Table 3.2.1-6). In 1975 and later, only trap nets with 8- and 10-ft cribs were fished in 6 m of water or less and the composition of freshwater drum in those years never exceeded 12% of the total catch. Hamley and Howley (1985) showed that the deeper set nets in 1971-1972 caught twice as many fish, mostly freshwater drum, quillback, white bass, carp and goldfish, whereas rock bass and other centrarchid species were more prevalent in the shallower set nets.

The observed high spatial and temporal variability in catches of even the most common species suggests that fish were clustered in distribution. Such variability suggests that the development of reliable indices of fish abundance may be unlikely with trap nets, except with an exorbitant amount of effort (Hamley and Howley 1985). The combined effects (including interactions) of location, season, and year in an ANOVA explained some 60% of the observed variability in log-transformed catches of yellow perch and rock bass (Table 3.2.1-14). Part of the variation not explained in the ANOVA models was subsequently indentified as relating to environmental factors.

### (i) Gear Selectivity

Like most other fishing gears, trap nets select for particular species and sizes of fish (Van Oosten et al. 1946, Grinstead and Gomez 1972, Laarman and Ryckman 1982) and therefore do not provide a true measure of community composition or species age composition (Grinstead 1970, Yeh 1977). The relatively large (2.0-2.25 in) mesh size of cribs in the 6-, 8-, and 10-ft trap nets at Nanticoke and Centre Creek failed to retain any age groups of the smaller fish species and juveniles of most species. No spottail and/or emerald shiners, very few (<1.0% of the total catch of yellow perch and rock bass) yearling yellow perch and rock bass, and very few rainbow smelt of any age were captured in trap nets (Table 3.2.1-7 and -8). Yet, these fish apparently were abundant in the Nanticoke area because they were taken frequently in large numbers by small mesh (<15 mm mesh) trawls, gill nets, and seines.

We did not attempt to correct for size selectivity of trap nets as have other investigators (Latta 1959, Laarman and Ryckman 1982). Furthermore, the differences we observed in size or age class composition among the various trapnet groups, particularly between the 6-ft (1.5 inch crib mesh) Centre Creek nets and the 8-ft Nanticoke nets (2.0-2.25 inch mesh), cannot conclusively be related to strictly gear selectivity because such effects could not be isolated from selectivity due to habitat variation among trapnet locations. Nevertheless, we recognize that the biases associated with size selectivity can be misleading in interpreting the effects of location, season, and year on catch. These concerns are addressed in greater detail in the subsequent discussions.

### (ii) Location

Differences in catch among the five Nanticoke locations, but not between the two Centre Creek locations, were significant for the two most common species (Table 3.2.1-14) and for several less frequently captured species or paired species (Table 3.2.1-16). Competition between Nanticoke nets probably was negligible because average distance between nets was some 2.1 km and minimum distance from shore was at least 300 m (Figure 3.2.1-1). In contrast the nets fished at Centre Creek were situated much closer to each other (approximately 200 m apart) and to shore (approximately 200 m offshore). While no significant difference in catch due to location were detected in the

Centre Creek nets, their catches may not have been independent of each other due to competition for capture of the same fish.

Habitat likely influenced catches among locations by affecting fish distribution and behaviour (Craig 1975, Laarman and Ryckman 1982) and gear performance (Hamley and Howley 1985). In contrast to the extensive sand-mud bottom found throughout most of western Long Point Bay, the lake bottom near Nanticoke was predominately rock (Heathcote 1981). Ontario Hydro surveys of nearshore sediments to 3-m depths indicate that the sediments in the wave zone were mostly loose rock and bedrock with some silt beds concentrated near the mouth of Nanticoke and Hickory Creek (Dunford 1980). Our own observations of bottom sediments near trapnet locations at Nanticoke (5-7 m water depths) and Centre Creek (3-m water depths) indicate a large component of mud-sand overlying bedrock (Table 3.2.1-32). The greatest contrast in sediment occurred between the NTGS plume and the other trapnet locations. The plume area consisted entirely of soft muds, but elsewhere bottom sediments were more diverse.

Submergent vegetation near all trapnet locations was sparse; when present, it consisted mostly of very short (<10 cm) attached algae and therefore provided minimal cover for fish. Rocks were the principle type of cover available to fish. Although differences in substrate and vegetation patterns were observed among trapnet sites we do not know to what extent these or other habitat features influenced fish catches. Nor do we know the nature or extent in which habitat might have changed over the survey period (1975-1983).

Differences in mesh size among trap nets might also have contributed to differences in catches among locations. Evidence of differential size- or age-class selectivity was most apparent between Centre Creek and Nanticoke trapnet catches (Table 3.2.1-19 and -24). Yellow perch, rock bass, and white bass captured at Centre Creek were smaller and younger than at Nanticoke; these species recruited into the Centre Creek nets at a smaller size within age groups, and at a faster rate through the growing season than they did in the Nanticoke nets (Figures 3.2.1-17, -19 to -22). Catch data of the two trapnet groups were analysed separately for these reasons and because they were sampled over different periods.

Except for possible selectivity due to competition between nets, the efficiencies of the two Centre Creek nets probably were similar because the mesh sizes of both nets were the same, and both nets were situated in similar habitats. However, mesh sizes differed among the five Nanticoke nets, (Table 3.2.1-1), and some significant differences in mean size, size at age, and age class composition of the major species were noted among these nets (Tables 3.2.1-21 and -24; Figure 3.2.1-18). In particular, the mesh size of the lead in the 10-ft Oneida trap net was more than twice as large (4.75 in.) as those of the other nets (2.0 in.), and mesh size of the crib in the East Brown's Point net (2.25 in.) was one-quarter of an inch larger than the other nets (2.0 in.). Although these nets tended to capture larger, older yellow perch and rock bass than most of the other Nanticoke nets, the effect was not consistent across years or even among seasons within a year. Furthermore, rock bass captured in the East Brown's Pt. net, which had the largest crib mesh among the

Nanticoke trap nets, more often were smaller than those caught in the other trap nets, rather than larger as was expected. Also peculiar was the larger mean size of yellow perch and larger size-at-age of rock bass (ages 4 and 5) captured in the Peacock Point net; this net had only 2.0 inch mesh throughout its components. These inconsistencies in the age and size composition of catches among the 8- and 10-ft trap nets (Nanticoke) suggest that selectivity was not entirely due to mesh size, but also to age- or size-specific habitat segregation of local fish populations (Latta 1959, Laarman and Ryckman 1982).

Selectivity due to gear and the environment probably was most complex in the thermal plume of the NTGS. Fish obviously were concentrated in the thermal plume as catches of the major species and several minor ones were higher there (West Plume) than at any other location in most years. Attractions of fish to waters heated by power plants has most often been attributed to environmental factors such as temperature, current, and food availability (Laundry and Strawn 1973, Marcy and Gavin 1973, Moore _et al_. 1973, Neill and Magnuson 1974). The two trap nets fished in the plume in 1982 and 1983 were slightly different in mesh size, and their catches differed significantly in terms of numbers and mean size of each species caught. Significantly, more but smaller fish were captured in the West Plume net than in the East Plume net, which had larger mesh in some of its components. Bottom sediments were the same at the two net sites and water temperatures at the east net averaged only slightly warmer (< 1.0° C) than at the west net. Site measurements of water current were not recorded; however, temperature distribution patterns (Metcalfe 1982, Wianko and Dixon

1983) suggest that discharge flows were stronger near the east than near the west net. Therefore, while mesh size selectivity probably accounted for some of the difference in the numbers and size of fish caught between the two plume nets, temperature and current patterns probably were contributing factors by influencing distribution and behaviour patterns of fish.

### (iii) Season

Significant seasonal fluctuations in fish catches such as those observed at Nanticoke (Table 3.2.1-14) are not uncommon; rather, they are typical of most lake (Craig 1975, Hall and Werner 1977, Dahlberg 1981) and riverine (Kelley 1953, Muncy 1962) populations. Peak catches of yellow perch and rock bass in spring suggest a strong along-shore movement of these species, possibly to spawning areas west of Nanticoke. This contention is supported by mark-recapture studies, which show a distinct westerly migration of rock bass and smallmouth bass and, to some extent, yellow perch from Nanticoke to Inner Bay in the spring each year (see Section 3.2.5). Why catches of rock bass in Nanticoke and Centre Creek nets, and catches of yellow perch in Centre Creek nets decreased after spring (Figures 3.2.1-3 and -4) may be related to natural and exploitation mortality, to migrations of fish from the study area, or to changes in their catchability due to seasonal changes in fish behaviour (Kelley 1953, Ryan 1984, Hamley and Howley 1985). Why catches of yellow perch in Nanticoke nets decreased to lowest levels in early summer following peak catches in spring, only to increase again in late summer (Figure 3.2.1-2) and fall may be due to the above-mentioned reasons and to the recruitment of two-year old perch. Age II yellow perch made up an increasingly larger portion of the total perch catch through spring, summer, and fall in all trap nets (Figures 3.2.1-19 and -20). The same seasonal trend was not observed in the Centre Creek nets and this may be because age II perch recruited into these nets earlier and at a faster rate through the growing season than they did in the larger meshed Nanticoke nets. The composition (%) of age II perch was higher in the 6-ft (Centre Creek) than in the 8- and 10-ft (Nanticoke) nets. In the latter group of trap nets, two-year olds represented less than 25% of the total yellow perch catch during spring and summer, but was the dominant (1981 and 1983) or co-dominant (1980) age group during the fall netting period. This was not true in 1982 because two-year olds were the product of a weak 1980 year class.

The frequency of age III yellow perch in Centre Creek catches declined steadily with season, but their percent composition in Nanticoke nets remained constant until the fall when the recruitment of two-year olds was strongest. Differences in seasonal trends of yellow perch abundance between the two trapnet groups reflect several possible processes including differential size selectivity, seasonal migrations, the selective removal of age III fish by commercial gillnets, and shifts in habitat preference of the age groups most vulnerable to the various trap nets. The relative importance of each of these selective processes can not be established and may vary from one year to the next depending on year class strengths, exploitation levels and habitat change. For species of minor commercial or recreational importance such as rock bass, seasonal varation in catch size and age composition due to gear selectivity was not strongly evident, partly because the population was represented by several relatively unexploited age classes and not just a few dominant, heavily exploited age classes as in the case of yellow perch. Kelley (1953) attributed seasonal fluctuations in trapnet catches of black crappie and several other species in the upper Mississippi River to recruitment, environmentally (temperature and water level) and physiologically induced changes in fish activity, and shifts in habitat preference of age groups vulnerable to the sampling gear.

### (iv) Year

Variations in annual catches of the major and less common species were extreme and highly significant (Table 3.2.1-14) in both groups of trap nets - Nanticoke and Centre Creek. Declining catches of rock bass and yellow perch after 1981 in the Nanticoke trap nets coincided with increased levels of operation by the three major industries at Nanticoke, but the two events probably were not related as the observed declines in fish abundance occurred mostly in areas removed from the principal source of industrial discharge (Figures 3.2.1-10 and -11). In fact, mean catches of yellow perch and rock bass in the NTGS plume were as high or higher during the operational period (1980-1983) than during a previous 4-year period (1975-1978). Furthermore, relative catch densities (1980-1983) in trap nets at Centre Creek do not support the notion of adverse industrial effects; mean catch per lift of yellow perch and rock bass increased significantly in the Centre Creek outfall (Figure 3.2.1-4) from 1980-1983 as did the number of trapnet lifts that caught one or more freshwater drum, white bass, white sucker, smallmouth bass, quillback, gizzard shad, crappie, sunfish, and bullhead (Figures 3.2.1-8 and -9). Coincident with these increases in relative fish abundance (at Centre Creek) was a substantial improvement in species diversity (Mean No. species per lift was 2.7 in 1980, 2.3 in 1981, 5.1 in 1982, and 5.4 in 1983).

Based on these findings, any general decline in fish numbers in the Nanticoke area probably was due to factors other than industry. Why the catches and numbers of fish species increased from 1980-1983 at Centre Creek's outfall is not clear, but may be related to changes in temperature and flow of the stream. Some alteration of natural stream temperature due to additions of Stelco's process water would seem to be a likely explanation, but is one we can not substantiate because long term temperature data were not available. However, Stelco's effluent clearly effluent augments natural stream flows in Centre Creek throughout the year, particularly in summer (Stelco 1978).

Much of the year-to-year variations in the catches of certain species appeared to be due to the relative strengths of year classes and their persistence in subsequent years. Age composition data of yellow perch, rock bass and smallmouth bass exhibit clearly the relative importance of the strong 1971 and 1977 year classes in annual trapnet catches from 1974 to 1983 (Figures 3.2.1-22 to -25). These year classes formed the dominant age group in up to four consecutive years of sampling. Even for the heavily exploited yellow perch, the 1971 year class persisted in trapnet catches for some five years.

That variations in trapnet catches at Nanticoke were typical of population fluctuations in Long Point Bay and other parts of Lake Erie is best demonstrated for yellow perch because of the long-time commercial importance of this species, and thus the availability of comparable data. To examine this, we compared our yearly trapnet indices for specific age classes of yellow perch captured in spring to stock size estimates (from cohort analysis) of yellow perch in eastern Lake Erie prepared by an international task force (Baker et al. 1985). In our initial examination we compared yearly stock size estimates of age III and older yellow perch with mean yearly trapnet catches (all ages) of perch (Figure 3.2.1-29A). Age III and older fish constituted some 75% or more of the perch catches in the 8- and 10-ft trapnets. The correlation ($r = 0.618$) between these two series of indices was non-significant ($P > 0.05$) when all available years (1974 - 1983, excluding 1979) of data were used. We did not expect trends in trapnet catches to match perfectly with the stock size estimates because of sampling biases (e.g. selectivity, differences in sampling period) associated with each index and because the stock size estimates included waters outside Long Point Bay. We focused on combinations of specific trapnet locations and age classes in an attempt to make the two data sets as comparable as possible and to avoid the problems of pooling locations with different selectivity components. The West Plume trap net was selected because it caught more fish than did the others. We compared the relative abundance (mean No./lift) of age III perch in that net with stock size estimates of age III perch in eastern Lake Erie (Figure 3.2.1-19C). The resultant correlation was poor ($r = 0.282$; $P > 0.05$) when all available years of data were included, but was significant ($P \leq 0.05$) with the 1982 index values excluded ($r = 0.736$). We also compared the relative numbers of age IV yellow perch caught in the Oneida trap net (which tended to catch larger and older fish) with age IV stock size estimates and found a highly significant ($P < 0.01$) correlation with ($r = 0.830$) or without ($r = 0.931$) the 1982 indices included (Figure 3.2.1-24B). These data indicate that annual catches of yellow perch, in Nanticoke trap nets were indeed a reflection of the age-specific abundance of yellow perch in Long Point Bay and eastern Lake Erie. Despite inconsistencies in some years -- most notably in 1982 -- year-to-year fluctuations in trapnet catches of yellow perch coincided with fluctuations in stock size.

Although estimates of stock size (or equivalent population parameters) were unavailable for other trapnetted species, there is some evidence suggesting that yearly variations in trapnet catches of the minor species were also related to the status of these populations in Long Point Bay and Lake Erie in general. For example, the 1980 year class, and to a lesser extent the 1977 year class of smallmouth bass showed strongly in trapnet catches at Nanticoke. These year classes also dominated angler harvests during the summer boat fishery on Long Point Bay in 1981 - 1984 (compare Figures 3.2.1-26 and 3.2.1-30). White perch, a recent invader of Lake Erie, were first observed in our trap nets in 1981, the same year they were first reported in commercial catches (compare Tables 3.2.1-7 and 3.2.2-15). The 1980 year class of white bass was particularly strong in trapnet catches (Figure 3.2.1-25) in 1981 (age I) and was also the dominate year class in Lake Erie commercial fish landings in 1982 and 1983 (compare Tables 3.2.1-7 and 3.2.2-15). Furthermore, the sharp increase in the relative abundance of gizzard shad in 1983 trapnet catches was indicative of a lake-wide population explosion (Table 3.2.2-15).

Collectively, these data suggest that annual fluctuations in the relative abundance of trapnetted species was related to factors influencing year class strengths, which were not unique to the Nanticoke area and therefore not linked to industrial activities. Large scale variations in year class abundance apparently are common among percids (LeCren 1955, Spangler et al. 1977), centrarchids (Dewey et al. 1981), and other freshwater (Henderson et al. 1983, Crecco and Savoy 1984, Henderson and Brown 1985) and marine (Leggett et al. 1984, Brett 1985, Overholtz et al. 1986) fish populations. Year-class strength, in general, is regulated by abiotic (Hile 1941, Clady 1976, Nelson and Walburg 1977, Smith 1977, Serns 1982) and biotic (Bagenal 1977, Johnson and Hale 1977, Henderson et al. 1983) factors of which temperature seems to be the most prominent (Koonce et al. 1977). We did not examine variations in year class strengths at Nanticoke for possible relationships with physical or biological factors. However, the wide spread similarity in year class variations of yellow perch (Baker et al. 1985) across Lake Erie suggests there is a strong abiotic influence acting on perch populations lakewide, possibly at the time of spawning and during early development.

### (v) Interactions

The effects of location on catches of rock bass, yellow perch and several minor species were not consistent across years or across seasons (Tables 3.2.1-14 and -16). Nor was the effect of season on catch consistent across years. The most significant of these interactions and the most difficult to explain was the year by location effect (Figures 3.2.1-5, -6, -10 and -11). Hamley and Howley

(1985) considered inconsistent sampling across years to be one possible explanation. Inconsistent sampling should not have been a factor in our studies (1975-1983) as it was in the earlier years (1971-1978) reported by Hamley and Howley (1985). Our analyses were based on standardized gear, locations, and sampling times. However, slight differences in the placement of trap nets from year to year may have differentially influenced the fishing efficency of some nets. In 1982 and 1983 net placements were aided by a Loran navigational aids, but all earlier net placements were accomplished visually. Slight differences in net placement relative to the variable bottom sediments, vegetation, and elevation patterns at Nanticoke could have influenced gear performance differently from one year to the next and thus explain some of the year by location variation.

Changing patterns in yearly catches of selected species among locations may also be related to industrial activities, in particular to increasing concentrations of fish at the NTGS plume coincident with a decrease in abundance of fish at the other trapnet locations (Figure 3.2.1-10). This shift in fish distribution patterns suggests that fish may have moved to the plume from other areas near Nanticoke, albeit not necessarily from the other trapnet locations. More probably the decrease in abundance of yellow perch observed at trapnet locations removed from the plume's influence was related to declines in basin-wide stock size (Figure 3.2.1-29) rather than to a redistribution of local populations. Factors responsible for concentrating yellow perch at the NTGS plume apparently were strongest in 1982 (spring) based on the increased disparity between the plume trapnet indices and stock size estimates. Apparently, these factors became more prominent in 1980 or later, and subsequently, the reliability of the plume location as an indicator of perch abundance declined.

Variations in weather from one year to the next may have been a factor contributing to a significant interaction of season with year. Another contributing factor was year class strength. Age II yellow perch became increasingly more vulnerable to trap nets through the growing season and their recruitment progressed more strongly in the smaller meshed nets at Centre Creek than in the 8- and 10-ft nets at Nanticoke (Figures 3.2.1-19 and -20). A particularly strong year class of yellow perch (eg. 1981) first contributed significantly to the total perch catch as two year olds (>40% of total perch catch) in the fall, whereas a weak year class (eg. 1980) was not a major component of the catch until the third year (age III). In general, seasonal patterns of yellow perch catches from year to year were determined in part by year class strengths, size or age selectivity characteristics of individual trap nets, and by seasonal and annual variations in commercial fishing effort (harvesting of age III and older perch).

An along-shore fish migration may help explain the significant interaction of location with season. The westerly movement of rock bass and yellow perch to spawning areas in the spring coincided with the highest seasonal catches at all locations, except for catches of yellow perch at East Brown's Pt. We suspect also that fish move alongshore and concentrate in areas where seasonal changes in habitat best approximate the preferred condition of individual species. Evidence of inshore-offshore migrations was not apparent in our studies because nets were set in similar depths of water. Hamley and Howley (1985) reported an inshore-offshore movement by quillback in the earlier years (1971-1972) when trap nets were set in pairs at different distances from shore. Alongshore and inshore-offshore movements have been reported elsewhere (e.g. Schumacher and Eschmeyer 1943; Van Oosten et al. 1946).

### (vi) Environmental Effects

Some of the variability in trapnet catches of yellow perch and rock bass not explained by the ANOVA's can be attributed to day-to-day changes in weather. While environmental variations in general, play an important role in the catch success of both sport and commercial fishermen, such observations have been largely casual rather than quantitative.

We found that trapnet catches were significantly associated with some environmental variables (Tables 3.2.1-33 and -34), but not consistently over seasons or between the two trapnet groups (Nanticoke versus Centre Creek nets). Nor were catches of the two most common species (yellow perch and rock bass) affected to the same extent by specific variables.

Significant correlations between trapnet catches and temperature suggests that the distribution patterns of fish or their vulnerability to capture were temperature dependent. Temperature has been identified from field and experimental studies as a principal factor controlling the activity levels (Fry 1947, 1967, and references cited in Coutant and Pfuderer 1973) and habitat utilization (Hall and

Werner 1977, Dahlberg 1981) by fish thereby influencing the vulnerability of fishes to passive netting gears. Lake temperatures during the summer growing season (June-August range: 7-24°C) at Nanticoke generally were negatively correlated with catches of yellow perch and rock bass in both trapnet groups (Tables 3.2 1-33 and -34). This suggests that these species were less active at warmer temperatures and therefore less susceptible to capture. Reduced fish catches with rising temperatures also have been observed in other water bodies (Kelley 1953, Scott 1970). In spring, the temperature-catch relationship at Nanticoke was complicated by other factors controlling the timing and nature of the alongshore spawning migrations of rock bass and yellow perch; consequently, no strong or consistent relationship was found during this period.

An offshore movement of yellow perch during cooling water temperatures in fall is indicated by a negative temperature-catch relationship at the inshore trapnet locations (Centre Creek) versus a positive temperature-catch relationship at the offshore locations (Nanticoke). Other investigators have reported a migration of yellow perch into deeper waters during fall (Harden-Jones 1968, Thorpe 1977b, Dahlberg 1981).

Decreased fish catches in Centre Creek nets and increased catches in Nanticoke nets were associated with increased wind speeds and decreased secchi transparencies; secchi transparencies and mean wind speeds were significantly correlated (Tables 3.2.1-33 and -34). These findings suggest that increased wind speeds caused fish to move offshore into deeper water where the effects of wave action (turbidity, etc) were less pronounced. We hypothesize that during such conditions, fish were more vulnerable to capture in the Nanticoke trap nets because they were concentrated and more active in the offshore waters, and the trap nets were less visible than during calm periods. Swenson (1977) observed increased feeding activities of walleye and sauger during periods of increased wave action and lake turbidity. Smallmouth bass in Lake Ontario apparently move into deeper waters (to 23-24 m) during storms (Stone 1949). In marine environments, as well, fish activities and distributions are reportedly influenced by frontal periods (May et al. 1976) and changes in wind direction (Scholes 1982).

One important exception to the above occurred in late summer when increased catches of yellow perch in Centre Creek nets were significantly correlated with increased wind speeds and onshore winds. This peculiarity suggests that the wind characteristics (direction and speed) in late summer differed in some way to those which prevailed in the other seasons. Winds in the Nanticoke area during late summer (1980-1983) were typically light (mean <15 km/h during 80% of the trapnet soak intervals) with very infrequent occurrences from an easterly or westerly (13% occurrences) direction (Figure 3.2.1-28). During the other seasons, winds were stronger (mean >15 km/h during 35-38% of the trapnet soak intervals) and more often (21-48% occurrences) from the east or west. Thus, the light onshore winds, which prevailed in late summer may not have been strong enough to displace fish into deeper waters, but perhaps were sufficient to at least induce greater swimming activity and increase their probability of capture.

The relationship of secchi transparency with fish catch could have been improved had secchi readings been taken more frequently during the interval between trapnet lifts (soak interval) instead of a single measurement each time nets were sampled, usually every third or fourth day. Similarly, correlations of catch with any of the environmental variables could have been improved had the soak interval between trapnet lifts been shorter. Our observations of environmental variables were measures of mean, mode, and maxima during specific soak intervals and these did not necessarily reflect ambient environmental conditions when most of the fish entered the trap nets.

## Summary

Long term trends in abundance, distribution and composition of primarily adult fish were examined in the littoral zone near Nanticoke with 8- to 10-ft. (crib size) trap nets fished at selected offshore (5-7 m depth) locations from Kitchen Pt. to Miller Pt. (Nanticoke trapnet study: 1971-1983) and with 6-ft nets fished near shore (3-m depths) at Centre Creek (Centre Creek trapnet study: 1980-1983). About 30 locations were sampled since 1971, but because of inconsistencies in methodology during the earlier years (1971-1974), statistical analyses were applied only to the locations and periods in which sampling design was standardized (1975-1983). For the Nanticoke trapnet study, standardized sampling included 8 years (1975-1983, excluding 1979), 4 seasons (spring, April 1-May 31; early summer, June 1-July 19; late summer, July 20-August 31; fall, September 1-October 31), and 5 locations (West Brown's Pt., East Brown's Pt., West Plume, Oneida, and Peacock Pt.). For the Centre Creek trapnet study, standardized sampling included 4 years (1980-1983), 4 seasons (same as for the Nanticoke trapnet study), and 2 locations (East and West Centre Creek).

More than 30 species were captured in the Nanticoke area since 1971, but only rock bass and yellow perch were caught in sufficient numbers to validate parametric analyses. Log transformed catches ($\log_{10} x + 1$) of these two species were fit into a 3-factorial ANOVA model and examined for variation due to year, season, and location. Catches of several minor species (freshwater drum, smallmouth bass, white bass, white sucker, gizzard shad and quillback) and "species pairs" (sunfish, crappie, bullhead) were categorized as either present (catch >0) or absent catch = 0) and analyzed by Logit analyses, a non-parametric procedure.

Yellow perch and rock bass dominated ($\geq$60% of total catch) trapnet catches at all locations. These species were present in 80% or more of 1,546 total lifts at Nanticoke and 358 total lifts at Centre Creek; whereas, 8 of the 9 minor species examined were absent from 70% of all trapnet lifts. Freshwater drum was the most frequently captured among the minor species (present in 43% of lifts in Nanticoke nets).

The effects of year, season, and location on trapnet catches of rock bass and yellow perch were highly significant ($P<0.001$). Combined, these factors and their interactions accounted for 60% of the total variation in catches of these species. The most notable difference among locations was the higher catches of fish at the NTGS thermal plume (West Plume net). Higher catches of most species, and more species per lift were exhibited in the West Plume trap net than in the other trap nets. Fish presumably were attracted to the warm water discharge because of temperature, current, and food availability.

Variations in habitat, and differential selectivity among individual trap nets (due to differences in mesh and crib size of some nets), probably accounted for much of the variation in catches of fish among locations; however, no consistent pattern was observed across years and across seasons. Inconsistencies in the effects of location on catches across years may have been caused by slight differences in net placement from year to year, relative to bottom habitat, which may have changed the efficiency of individual nets from one year to the next.

Seasonal variations in species catches were highly significant ($P<0.001$). Catches of rock bass and yellow perch peaked during the spring spawning migration period, where as catches of sunfish, crappie, bullhead, gizzard shad, quillback and white bass peaked in late summer or fall. Declines in catches of rock bass and yellow perch in Centre Creek nets and rock bass in Nanticoke nets after spring probably were caused by natural and exploitation mortality, migrations of fish from the study area, and changes in behavior-related catchabilities of age groups vulnerable to the sampling gear. Catches of yellow perch in the Nanticoke trap nets did not follow the above seasonal pattern, partly because of differences in age- or- size specific recruitment between the two trapnet groups. Peak catches in spring in Nanticoke nets typically were followed by lowest catches (in early summer) and then by increasing catches in late summer and fall. Recruitment of age II perch occurred earlier and progressed more strongly through the growing season in the 6-ft Centre Creek nets than in the 8- to 10-ft Nanticoke trap nets. Recruitment (age II) of variable year class strengths, variations in commercial fishing effort (harvesting of age III), and fluctuations in weather likely contributed to inconsistent seasonal patterns in catches of yellow perch in trap nets from year to year.

Annual catches of most fish species fluctuated considerably at all trapnet locations, but not in any discernable pattern. That could be directly linked to industry. Indices of annual abundance of age III and IV yellow perch were correlated with stock size estimates (from cohort analysis) of perch in eastern Lake Erie. Strong year classes of rock bass persisted in trapnet catches for several years, whereas strong year classes of yellow perch rapidly declined due to heavy commercial exploitation of age III and older fish. Strong year classes also were observed in several minor species (white bass, smallmouth bass, gizzard shad). This evidence suggests that yearly fluctuations in trapnet catches of selected species reflect lake wide trends in year class strengths.

Day-to-day variations in trapnet catches of rock bass and yellow perch were correlated with environmental variables. Catches of these species varied inversely with water temperatures during summer, which suggests that fish moved out of the study area or were less active at higher water temperatures. Strong onshore winds resulted in increased wave activity and reduced inshore water transparencies. These conditions apparently induced fish to move into deeper waters. Fish probably were more vulnerable to trap nets during stormy periods because they were more active and the nets were less visible.

Table 3.2.1-1. Crib size, lead length, and component mesh size of trap nets fished near Nanticoke (1975-1983) and Centre Creek (1980-1983), Long Point Bay, Lake Erie.

| TRAPNET LOCATION | YEARS SAMPLED | CRIB SIZE (ft)++ | LEAD LENGTH (ft)++ | Stretched Mesh Size (in) of Trapnet Component++ | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | CRIB | FUNNEL | HEART | WINGS | LEAD |
| Selkirk | 1975-81* | 8 | 200 | 2 | 2.5 | 2.5 | 2.5 | 2 |
| Peacock Pt.+ | 1975-83 | 8 | 200 | 2 | 2 | 2 | 2 | 2 |
| Oneida+ | 1975-83 | 10 | 300 | 2 | 2 | 2 | 2 | 4.75 |
| East Plume | 1982-83 | 8 | 200 | 2 | 2.5 | 2.5 | 2.5 | 2 |
| West Plume+ | 1975-83 | 8 | 200 | 2 | 2 | 2 | 2 | 2 |
| East Brown's Pt.+ | 1975-83 | 8 | 200 | 2.25 | 2.25 | 2.25 | 2.25 | 2 |
| West Brown's Pt.+ | 1975-83 | 8 | 200 | 2 | 2 | 2 | 2 | 2 |
| East Center Ck.+ | 1980-83 | 6 | 125 | 1.5 | 1.5 | 1.5 | 1.5 | 2.25 |
| Mid Center Ck. | 1982 | 6 | 125 | 1.5 | 1.5 | 1.5 | 1.5 | 2.25 |
| West Center Ck.+ | 1980-83 | 6 | 125 | 1.5 | 1.5 | 1.5 | 1.5 | 2.25 |

* Sampling at Selkirk was discontinued June 1, 1981.

+ Standard trapnet location.

++ Metric Equivalents: 1.5 in = 38 mm; 2 in = 51 mm; 2.25 in = 57 mm; 2.5 in = 64 mm; 4.75 in = 121 mm; 6 ft = 1.8 m; 8 ft = 2.4 m; 10 ft = 3.0 m; 125 ft = 38.1 m; 200 ft = 61.0 m; 300 ft = 91.4 m.

Table 3.2.1-2. Trapnet sampling sites (Site No.) before (1971-1974) and after (1975-1983) the establishment of standard locations. Site numbers correspond to those in Figure 3.2.1-1.

| Location Name | Sites pooled in 1971-1974 | Standard Locations 1975-1983 | Supplementary sites sampled after 1974 |
|---|---|---|---|
| Selkirk | 1-5 | | 2 |
| Peacock Point | 6-8 | 6 | |
| Oneida | 9-11 | 10 | |
| East Plume | | | 13 |
| West Plume | 12 | 12 | |
| East Brown's Point | 14, 15, 17 | 15 | |
| West Brown's Point | 22-28 | 22 | |
| East Centre Creek | | 50 | |
| Mid Centre Creek | | | 52 |
| West Centre Creek | | 51 | |

Table 3.2.1-3. Number of trapnet lifts by location, crib size, and year in Long Point Bay, Lake Erie, 1971-1983.

| Location | Crib Size (ft ) | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Selkirk | 8 | 1 | 4 | 6 | 11 | 14 | 31 | 30 | 25 | 35 | 6 | | |
| | 12 | | 5 | 1 | | | | | | | | | |
| Peacock Pt. | 8 | 8 | 14 | 1 | | 28 | 29 | 28 | 27 | 35 | 41 | 50 | 45 |
| | 12 | 9 | 13 | 6 | | | | | | | | | |
| Oneida | 8 | 7 | | 1 | | | | | | | | | |
| | 10 | | | | 37 | 33 | 34 | 44 | 33 | 39 | 44 | 49 | 46 |
| | 12 | 8 | | 1 | | | | | | | | | |
| East Plume | 8 | | | | | | | | | | | 49 | 45 |
| West Plume | 8 | | | | 39 | 28 | 40 | 44 | 28 | 37 | 42 | 50 | 45 |
| E. Brown's Pt. | 8 | | | 6 | | 33 | 41 | 42 | 31 | 36 | 43 | 49 | 44 |
| | 12 | | | 1 | | | | | | | | | |
| W. Brown's Pt. | 8 | 15 | 20 | 1 | 23 | 30 | 39 | 41 | 32 | 35 | 40 | 47 | 44 |
| | 10 | | 5 | | | | | | | | | | |
| | 12 | 19 | 21 | 6 | 9 | | | | | | | | |
| E. Centre Creek. | 6 | | | | | | | | | 45 | 45 | 49 | 43 |
| Mid Centre Creek | 6 | | | | | | | | | | | 48 | |
| W. Centre Creek | 6 | | | | | | | | | 45 | 39 | 48 | 44 |

Table 3.2.1-4. Number of lifts and mean No. of days trap nets fished ($\bar{x}$ soakdays) between lifts at Nanticoke and Centre Creek standard locations by location and year (April - October).

| LOCATION | STATISTIC | YEAR<br>1975 | 1976 | 1977 | 1978 | 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|---|---|---|---|---|
| NANTICOKE TRAP NETS | | | | | | | | | |
| Peacock Pt. | No. lifts | 28 | 29 | 28 | 27 | 35 | 41 | 50 | 45 |
| | $\bar{x}$ soakdays | 4.8 | 5.6 | 7.0 | 6.7 | 5.1 | 4.3 | 3.7 | 4.0 |
| | (± SD) | (2.11) | (2.43) | (3.17) | (3.16) | (2.71) | (2.06) | (1.21) | (1.48) |
| Oneida | No. lifts | 33 | 34 | 44 | 33 | 39 | 44 | 49 | 46 |
| | $\bar{x}$ soakdays | 4.1 | 4.9 | 4.5 | 5.7 | 4.7 | 4.0 | 3.7 | 3.9 |
| | (± SD) | (2.11) | (2.61) | (1.96) | (4.03) | (2.17) | (1.55) | (1.21) | (1.42) |
| W. Plume | No. lifts | 28 | 40 | 44 | 28 | 37 | 42 | 50 | 45 |
| | $\bar{x}$ soakdays | 4.3 | 4.3 | 4.5 | 6.0 | 4.8 | 4.2 | 3.7 | 4.2 |
| | (± SD) | (1.65) | (2.25) | (1.92) | (4.15) | (2.27) | (1.85) | (1.21) | (1.82) |
| E. Brown's Pt. | No. lifts | 33 | 41 | 42 | 31 | 36 | 43 | 49 | 44 |
| | $\bar{x}$ soakdays | 4.1 | 4.1 | 4.7 | 5.7 | 5.1 | 4.1 | 3.6 | 4.1 |
| | (± SD) | (1.75) | (1.95) | (2.25) | (3.35) | (2.30) | (1.55) | (1.20) | (1.74) |
| W. Brown's Pt. | No. lifts | 30 | 39 | 41 | 32 | 35 | 40 | 47 | 44 |
| | $\bar{x}$ soakdays | 4.0 | 4.3 | 4.4 | 5.5 | 5.2 | 4.4 | 3.7 | 4.1 |
| | (± SD) | (1.73) | (2.13) | (2.63) | (3.40) | (2.72) | (2.35) | (1.34) | (1.59) |
| TOTAL | No. lifts | 152 | 183 | 199 | 151 | 182 | 210 | 245 | 224 |
| | $\bar{x}$ soakdays | 4.3 | 4.5 | 4.9 | 5.9 | 5.0 | 4.2 | 3.7 | 4.1 |
| | (± SD) | (1.81) | (2.30) | (2.50) | (3.62) | (2.42) | (1.87) | (1.22) | (1.63) |
| CENTRE CREEK TRAP NETS | | | | | | | | | |
| E. Centre Ck. | No. lifts | | | | | 45 | 45 | 49 | 43 |
| | $\bar{x}$ soakdays | | | | | 4.1 | 3.9 | 3.6 | 4.2 |
| | (± SD) | | | | | (1.22) | (1.58) | (1.17) | (1.62) |
| W. Centre Ck. | No. lifts | | | | | 45 | 39 | 48 | 44 |
| | $\bar{x}$ soakdays | | | | | 4.1 | 4.5 | 3.6 | 4.1 |
| | (± SD) | | | | | (1.22) | (3.27) | (1.18) | (1.55) |
| TOTAL | No. lifts | | | | | 90 | 84 | 97 | 87 |
| | $\bar{x}$ soakdays | | | | | 4.1 | 4.2 | 3.6 | 4.1 |
| | (± SD) | | | | | (1.21) | (2.51) | (1.17) | (1.57) |

Table 3.2.1-5 Number of lifts and mean No. of days trap nets fished ($\bar{x}$ soakdays) between lifts at Nanticoke (1975 - 1983) and Centre Creek (1980 - 1983) standard locations by location and season.

| SEASON | STATISTIC | YEAR<br>1975 | 1976 | 1977 | 1978 | 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|---|---|---|---|---|
| | | NANTICOKE TRAP NETS<br>(Peacock Pt., Oneida, West Plume, E. Brown's Pt., W. Brown's Pt.) | | | | | | | |
| Spring | No. lifts | 43 | 47 | 55 | 31 | 34 | 36 | 44 | 46 |
| | $\bar{x}$ soakdays | 3.6 | 4.3 | 4.2 | 5.3 | 4.1 | 3.5 | 3.7 | 3.6 |
| | (± SD) | (1.28) | (1.67) | (1.88) | (1.83) | (1.62) | (1.03) | (1.14) | (1.22) |
| Early Summer | No. lifts | 40 | 38 | 53 | 41 | 48 | 64 | 70 | 60 |
| | $\bar{x}$ soakdays | 4.1 | 4.0 | 4.1 | 3.9 | 5.2 | 3.8 | 3.5 | 4.1 |
| | (± SD) | (1.57) | (2.22) | (2.09) | (3.57) | (3.62) | (1.55) | (0.74) | (1.62) |
| Late Summer | No. lifts | 38 | 46 | 48 | 47 | 40 | 56 | 60 | 52 |
| | $\bar{x}$ soakdays | 4.0 | 4.4 | 4.9 | 5.0 | 5.2 | 3.8 | 3.6 | 4.0 |
| | (± SD) | (1.98) | (2.58) | (2.69) | (2.29) | (2.02) | (1.44) | (0.96) | (1.43) |
| Fall | No. lifts | 31 | 52 | 43 | 32 | 60 | 54 | 71 | 66 |
| | $\bar{x}$ soakdays | 5.7 | 5.4 | 6.7 | 7.9 | 5.1 | 5.6 | 3.9 | 4.4 |
| | (± SD) | (1.79) | (2.41) | (2.60) | (5.49) | (1.67) | (2.35) | (1.74) | (1.98) |
| | | EAST AND WEST CENTRE CREEK TRAP NETS | | | | | | | |
| Spring | No. lifts | | | | | 18 | 16 | 16 | 18 |
| | $\bar{x}$ soakdays | | | | | 3.4 | 3.6 | 3.4 | 3.3 |
| | (± SD) | | | | | (0.86) | (1.36) | (0.96) | (0.97) |
| Early Summer | No. lifts | | | | | 24 | 28 | 27 | 26 |
| | $\bar{x}$ soakdays | | | | | 4.1 | 3.5 | 3.5 | 3.8 |
| | (± SD) | | | | | (1.14) | (0.51) | (0.75) | (1.07) |
| Late Summer | No. lifts | | | | | 20 | 16 | 24 | 19 |
| | $\bar{x}$ soakdays | | | | | 4.2 | 4.6 | 3.5 | 4.4 |
| | (± SD) | | | | | (1.20) | (2.58) | (0.83) | (1.71) |
| Fall | No. lifts | | | | | 28 | 24 | 30 | 24 |
| | $\bar{x}$ soakdays | | | | | 4.4 | 5.0 | 3.9 | 4.8 |
| | (± SD) | | | | | (1.37) | (3.90) | (1.68) | (1.95) |

Table 3.2.1-6. Number of lifts and mean No. of days ($\bar{x}$ soakdays) trap nets fished between lifts at Nanticoke and Centre Creek standard locations by season and year.

| | | SEASON | | | | |
|---|---|---|---|---|---|---|
| LOCATION | STATISTIC | SPRING | EARLY SUMMER | LATE SUMMER | FALL | TOTAL |
| | | NANTICOKE TRAP NETS | | | | |
| Peacock Pt. | No. lifts | 61 | 72 | 73 | 77 | 283 |
| | $\bar{x}$ soakdays | 4.4 | 4.9 | 4.5 | 5.8 | 4.9 |
| | (± SD) | (1.73) | (2.85) | (2.01) | (2.88) | (2.50) |
| Oneida | No. lifts | 68 | 86 | 82 | 86 | 322 |
| | $\bar{x}$ soakdays | 4.0 | 4.2 | 4.0 | 5.1 | 4.4 |
| | (± SD) | (1.55) | (2.13) | (1.79) | (2.85) | (2.21) |
| W. Plume | No. lifts | 67 | 86 | 79 | 82 | 314 |
| | $\bar{x}$ soakdays | 3.9 | 4.1 | 4.2 | 5.3 | 4.4 |
| | (± SD) | (1.56) | (2.11) | (1.80) | (2.88) | (2.22) |
| E. Brown's Pt. | No. lifts | 70 | 87 | 77 | 85 | 319 |
| | $\bar{x}$ soakdays | 3.8 | 4.0 | 4.3 | 5.2 | 4.4 |
| | (± SD) | (1.42) | (1.97) | (2.00) | (2.49) | (2.10) |
| W. Brown's Pt. | No. lifts | 70 | 83 | 76 | 79 | 308 |
| | $\bar{x}$ soakdays | 3.8 | 4.2 | 4.5 | 5.1 | 4.4 |
| | (± SD) | (1.56) | (2.40) | (2.48) | (2.52) | (2.33) |
| TOTAL | No. lifts | 336 | 414 | 387 | 409 | 1546 |
| | $\bar{x}$ soakdays | 4.0 | 4.2 | 4.3 | 5.3 | 4.5 |
| | (± SD) | (1.57) | (2.30) | (2.02) | (2.73) | (2.28) |
| | | CENTRE CREEK TRAP NETS | | | | |
| E. Centre Ck. | No. lifts | 34 | 53 | 41 | 54 | 182 |
| | $\bar{x}$ soakdays | 3.4 | 3.7 | 4.1 | 4.4 | 3.9 |
| | (± SD) | (1.05) | (0.91) | (1.49) | (1.80) | (1.41) |
| W. Centre Ck. | No. lifts | 34 | 52 | 38 | 52 | 176 |
| | $\bar{x}$ soakdays | 3.5 | 3.7 | 4.2 | 4.7 | 4.1 |
| | (± SD) | (1.02) | (0.91) | (1.82) | (2.85) | (1.94) |
| TOTAL | No. lifts | 68 | 105 | 79 | 106 | 358 |
| | $\bar{x}$ soakdays | 3.5 | 3.7 | 4.1 | 4.5 | 4.0 |
| | (± SD) | (1.03) | (0.91) | (1.65) | (2.37) | (1.69) |

Table 3.2.1-7. Taxonomic composition (% of total catch) and summary statistics of fish catches in 8-, 10-, and 12-ft trap nets at Nanticoke, 1971-1983 (April to October).[1]

| SPECIES | YEAR | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1980 | 1981 | 1982 | 1983 |
| Rock Bass | 9.7 | 16.7 | 10.7 | 36.5 | 37.5 | 45.7 | 41.1 | 43.5 | 31.1 | 33.9 | 31.5 | 42.2 |
| Yellow Perch | 7.1 | 27.8 | 6.8 | 25.1 | 28.3 | 22.1 | 35.4 | 28.2 | 40.1 | 36.3 | 45.3 | 23.4 |
| Walleye | 0.2 | 0.3 | 2.3 | 0.8 | < 0.1 | 0.4 | 0.2 | 0.5 | 0.1 | 0.1 | 0.1 | < 0.1 |
| Freshwater Drum | 29.0 | 33.4 | 45.3 | 12.5 | 11.7 | 11.4 | 7.7 | 5.6 | 9.6 | 2.5 | 4.6 | 10.5 |
| Smallmouth Bass | 4.7 | 1.1 | 3.0 | 4.8 | 2.3 | 2.6 | 2.1 | 3.5 | 2.1 | 2.3 | 3.4 | 1.3 |
| Largemouth Bass | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | < 0.1 | 0.0 |
| White Bass | 13.6 | 3.6 | 2.3 | 0.8 | 2.0 | 1.4 | 0.7 | 8.5 | 0.7 | 11.4 | 3.4 | 0.9 |
| White Sucker | 21.1 | 9.0 | 8.6 | 4.5 | 2.1 | 5.3 | 3.0 | 3.1 | 4.7 | 4.3 | 3.7 | 1.8 |
| Redhorse Sucker | 2.0 | 0.9 | 0.3 | 0.4 | 0.0 | 0.7 | 0.1 | 0.4 | 1.1 | 0.7 | 1.0 | 0.4 |
| Lamprey | < 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Bowfin | < 0.1 | < 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | < 0.1 | < 0.1 | 0.0 |
| Bluegill | 1.2 | 0.2 | 0.4 | 0.1 | 0.0 | 0.0 | 0.0 | < 0.1 | 0.1 | < 0.1 | 0.1 | < 0.1 |
| Pumpkinseed | 0.0 | 0.0 | 0.0 | 5.4 | 1.9 | 1.4 | 0.4 | 0.1 | 0.3 | 0.4 | 0.3 | 0.5 |
| White Crappie | 2.7 | 0.5 | 8.0 | 5.0 | 6.5 | 5.7 | 4.5 | 3.1 | 3.2 | 1.2 | 0.5 | 0.8 |
| Black Crappie | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.6 | 0.3 | 0.1 | 0.3 | 0.2 |
| Gizzard Shad | 2.5 | 3.4 | 4.6 | 0.6 | 1.4 | < 0.1 | 1.3 | 0.1 | 0.3 | 0.5 | < 0.1 | 5.2 |
| Madtom | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | < 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Carp | 1.1 | 0.7 | 1.3 | 0.4 | 1.1 | 0.9 | 1.4 | 0.6 | 0.5 | 0.4 | 0.2 | 0.3 |
| Goldfish | 0.2 | 0.1 | 0.0 | < 0.1 | 0.0 | < 0.1 | 0.0 | 0.0 | < 0.1 | < 0.1 | 0.0 | 0.0 |
| Coho | < 0.1 | 0.1 | 0.0 | < 0.1 | 0.0 | 0.0 | 0.0 | < 0.1 | < 0.1 | 0.0 | 0.0 | 0.0 |
| Rainbow Trout | < 0.1 | 0.0 | 0.0 | < 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | < 0.1 | 0.0 |
| Lake Trout | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | < 0.1 | 0.0 | 0.0 |
| Rainbow Smelt | 0.0 | < 0.1 | 0.0 | 0.0 | 0.1 | < 0.1 | 0.0 | 0.0 | < 0.1 | 0.0 | 0.0 | < 0.1 |
| Northern Pike | 0.1 | 0.0 | 0.3 | < 0.1 | < 0.1 | 0.0 | < 0.1 | < 0.1 | 0.0 | 0.0 | < 0.1 | < 0.1 |
| Gar Pike | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | < 0.1 | < 0.1 | < 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Yellow Bullhead | 0.0 | 0.0 | 0.4 | 0.4 | 0.4 | 0.5 | 0.6 | 0.6 | 3.2 | 1.7 | 1.5 | 0.4 |
| Brown Bullhead | 1.3 | 0.1 | 0.0 | 0.2 | < 0.1 | 0.2 | 0.3 | < 0.1 | 0.0 | 0.1 | 0.0 | 0.0 |
| Channel Catfish | 0.9 | 0.2 | 1.7 | 1.0 | 0.7 | 0.6 | 0.2 | 0.3 | 0.8 | 0.2 | 0.3 | 0.2 |
| Sturgeon | 0.0 | < 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Eel | 0.0 | 0.0 | 0.0 | < 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mooneye | 0.2 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | < 0.1 | 0.0 | 0.1 | < 0.1 | 0.0 |
| Burbot | 0.0 | 0.0 | 0.0 | < 0.1 | 0.0 | 0.0 | 0.0 | < 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Stonecat | 0.1 | 0.0 | 0.0 | 0.2 | < 0.1 | 0.2 | 0.1 | 0.2 | 0.2 | 0.5 | 0.3 | 0.2 |
| Quillback | 1.7 | 1.3 | 3.6 | 0.8 | 1.3 | 0.7 | 0.5 | 1.1 | 1.5 | 1.8 | 2.0 | 1.4 |
| Alewife | 0.5 | 0.8 | 0.0 | 0.2 | 2.2 | 0.1 | 0.0 | < 0.1 | 0.[illegible] | 0.1 | 0.1 | 0.2 |
| Sauger | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | < 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| White Perch | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.9 | 1.2 | 10.0 |
| Unidentified | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | < 0.1 | 0.0 | 0.0 | < 0.1 |
| **STATISTIC** | | | | | | | | | | | | |
| No. Fish | 3145.0 | 3358.0 | 689.0 | 6376.0 | 2256.0 | 5526.0 | 6928.0 | 5559.0 | 4771.0 | 9077.0 | 7026.0 | 7009.0 |
| No. Lifts | 67.0 | 82.0 | 30.0 | 119.0 | 152.0 | 183.0 | 199.0 | 151.0 | 182.0 | 210.0 | 245.0 | 224.0 |
| Mean catch/lift | 46.9 | 41.0 | 23.0 | 53.6 | 14.8 | 30.2 | 34.8 | 36.8 | 26.2 | 43.2 | 28.7 | 31.3 |

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[1] 1971-74 data are for Selkirk, Peacock Point, Oneida, West Plume, East Brown's Point and West Brown's Point; 1975-83 data are for standard locations: Peacock Point, Oneida, West Plume, East Brown's Point, and West Brown's Point.

Table 3.2.1-8. Taxonomic composition (% of total catch) and summary statistics of fish catches in 6-ft trap nets at Centre Creek standard locations, 1980-1983 (April - October).

| SPECIES | YEAR 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|
| Rock bass | 36.7 | 26.8 | 44.9 | 54.1 |
| Yellow perch | 47.0 | 36.8 | 37.9 | 24.3 |
| Freshwater drum | 1.2 | 1.5 | 0.5 | 2.7 |
| Smallmouth bass | 0.1 | 0.1 | 3.3 | 2.5 |
| Largemouth bass | 0.0 | 0.0 | 0.0 | <0.1 |
| White bass | 11.0 | 24.4 | 7.6 | 4.6 |
| White sucker | 0.9 | 0.8 | 1.0 | 3.6 |
| Redhorse sucker | 0.3 | 0.1 | 0.2 | 0.5 |
| Lamprey | 0.0 | 0.1 | 0.0 | 0.0 |
| Bowfin | 0.0 | 0.1 | <0.1 | <0.1 |
| Bluegill | <0.1 | 0.1 | 0.1 | 0.5 |
| Pumpkinseed | 0.1 | 0.2 | 0.6 | 0.5 |
| White crappie | 0.9 | 0.3 | 0.6 | 1.0 |
| Black crappie | 0.4 | 0.7 | 0.2 | 0.2 |
| Gizzard shad | 0.1 | 0.0 | 0.2 | 0.6 |
| Carp | 0.1 | 0.1 | 0.1 | 0.3 |
| Goldfish | <0.1 | 0.1 | <0.1 | <0.1 |
| Northern pike | 0.0 | 0.0 | <0.1 | 0.0 |
| Gar pike | 0.0 | 0.0 | <0.1 | 0.0 |
| Yellow bullhead | 0.1 | 0.2 | 1.1 | 0.4 |
| Brown bullhead | 0.0 | 0.2 | 0.1 | <0.1 |
| Channel catfish | 0.1 | 3.2 | 0.2 | 0.1 |
| Eel | <0.1 | 0.0 | 0.0 | <0.1 |
| Burbot | 0.0 | 0.0 | 0.0 | <0.1 |
| Stonecat | 0.4 | 3.1 | 0.2 | 0.5 |
| Quillback | 0.5 | 0.1 | 0.3 | 0.4 |
| Alewife | 0.1 | 0.1 | 0.2 | 0.7 |
| White perch | 0.0 | 0.8 | 0.9 | 2.2 |
| Unidentified | 0.0 | 0.1 | 0.0 | 0.0 |
| SUMMARY STATISTICS | | | | |
| No. Fish | 2689 | 914 | 7204 | 4568 |
| No. Lifts | 90 | 84 | 97 | 87 |
| mean catch/lift | 29.9 | 10.9 | 74.3 | 52.5 |

Table 3.2.1-9. Maximum and mean (±SD) No. of fish taxa caught per lift in trap nets at standard Nanticoke and Centre Creek locations.

| Summary by: Location Season Year | Nanticoke Trap Nets | | | Centre Creek Trap Nets | | |
|---|---|---|---|---|---|---|
| | Maximum | Mean | SD | Maximum | Mean | SD |
| **LOCATION** | | | | | | |
| Peacock Pt. | 13 | 4.3 | 2.8 | | | |
| Oneida | 13 | 4.9 | 2.7 | | | |
| West Plume | 15 | 5.5 | 3.0 | | | |
| East Brown's Pt. | 10 | 2.9 | 1.9 | | | |
| West Brown's Pt. | 8 | 2.8 | 1.7 | | | |
| East Centre Creek | | | | 11 | 4.0 | 2.7 |
| West Centre Creek | | | | 15 | 3.8 | 2.6 |
| **SEASON** | | | | | | |
| Spring | 13 | 4.1 | 2.5 | 15 | 5.2 | 3.1 |
| Early Summer | 9 | 2.9 | 1.8 | 10 | 3.4 | 2.2 |
| Late Summer | 15 | 4.7 | 2.9 | 12 | 3.8 | 2.3 |
| Fall | 15 | 4.7 | 3.1 | 11 | 3.8 | 2.6 |
| **YEAR** | | | | | | |
| 1975 | 11 | 3.3 | 2.1 | | | |
| 1976 | 13 | 4.1 | 2.5 | | | |
| 1977 | 12 | 4.1 | 2.6 | | | |
| 1978 | 12 | 4.4 | 2.6 | | | |
| 1980 | 13 | 4.1 | 2.3 | 10 | 2.7 | 1.6 |
| 1981 | 15 | 4.7 | 3.3 | 8 | 2.3 | 1.5 |
| 1982 | 13 | 4.0 | 2.7 | 11 | 5.1 | 2.5 |
| 1983 | 13 | 3.8 | 3.0 | 15 | 5.4 | 2.9 |

Table 3.2.1-10. Percent of trapnet lifts that caught fish (catch > 0) of a specified kind at standard Nanticoke locations by year and location (April - October).[1]

| LOCATION | No. lifts | SPECIES<br>Rock bass | Yellow perch | FW. drum | Smallmouth bass | White bass | White sucker | Sunfish | Crappie | Gizzard shad | Bullhead | Quillback |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1 9 7 5 | | | | | | |
| Peacock Pt. | 28 | 54 | 71 | 54 | 7 | 4 | 4 | 7 | 18 | 11 | 4 | 21 |
| Oneida | 33 | 76 | 82 | 82 | 30 | 18 | 33 | 6 | 18 | 15 | 0 | 24 |
| West Plume | 28 | 75 | 96 | 18 | 18 | 0 | 7 | 14 | 32 | 4 | 7 | 4 |
| E. Brown's Pt. | 33 | 67 | 88 | 36 | 36 | 27 | 15 | 33 | 45 | 3 | 15 | 12 |
| W. Brown's Pt. | 30 | 70 | 83 | 10 | 10 | 10 | 10 | 7 | 17 | 0 | 0 | 3 |
| TOTAL | 152 | 68 | 84 | 41 | 16 | 13 | 14 | 14 | 26 | 7 | 5 | 13 |
| | | | | | | 1 9 7 6 | | | | | | |
| Peacock Pt. | 29 | 59 | 97 | 21 | 14 | 14 | 21 | 3 | 31 | 3 | 7 | 7 |
| Oneida | 34 | 91 | 94 | 71 | 59 | 32 | 68 | 6 | 38 | 3 | 26 | 18 |
| West Plume | 40 | 85 | 80 | 58 | 15 | 10 | 28 | 8 | 50 | 0 | 5 | 10 |
| E. Brown's Pt. | 41 | 98 | 83 | 44 | 34 | 22 | 22 | 34 | 63 | 0 | 29 | 12 |
| W. Brown's Pt. | 39 | 85 | 62 | 10 | 23 | 3 | 5 | 10 | 8 | 0 | 0 | 0 |
| TOTAL | 183 | 85 | 82 | 41 | 29 | 16 | 28 | 13 | 39 | 1 | 14 | 9 |
| | | | | | | 1 9 7 7 | | | | | | |
| Peacock Pt. | 28 | 43 | 54 | 14 | 0 | 4 | 7 | 4 | 11 | 0 | 0 | 7 |
| Oneida | 44 | 82 | 100 | 75 | 50 | 27 | 59 | 0 | 18 | 30 | 9 | 25 |
| West Plume | 44 | 100 | 98 | 52 | 39 | 20 | 27 | 11 | 52 | 27 | 50 | 9 |
| E. Brown's Pt. | 42 | 76 | 98 | 45 | 17 | 14 | 12 | 5 | 45 | 2 | 12 | 0 |
| W. Brown's Pt. | 41 | 90 | 88 | 22 | 24 | 10 | 29 | 10 | 22 | 5 | 7 | 7 |
| TOTAL | 199 | 82 | 90 | 44 | 28 | 16 | 29 | 6 | 31 | 14 | 17 | 10 |
| | | | | | | 1 9 7 8 | | | | | | |
| Peacock Pt. | 27 | 85 | 89 | 44 | 7 | 44 | 15 | 0 | 11 | 4 | 0 | 11 |
| Oneida | 33 | 82 | 100 | 82 | 55 | 76 | 64 | 3 | 18 | 15 | 0 | 42 |
| West Plume | 28 | 93 | 89 | 32 | 21 | 32 | 36 | 7 | 46 | 0 | 32 | 0 |
| E. Brown's Pt. | 31 | 58 | 74 | 35 | 10 | 13 | 10 | 3 | 39 | 0 | 0 | 0 |
| W. Brown's Pt | 32 | 100 | 94 | 44 | 44 | 63 | 25 | 0 | 25 | 0 | 16 | 19 |
| TOTAL | 151 | 83 | 89 | 48 | 28 | 46 | 30 | 3 | 28 | 4 | 9 | 15 |
| | | | | | | 1 9 8 0 | | | | | | |
| Peacock Pt. | 35 | 91 | 100 | 69 | 46 | 23 | 83 | 9 | 46 | 3 | 54 | 34 |
| Oneida | 39 | 69 | 90 | 77 | 10 | 8 | 28 | 0 | 15 | 10 | 0 | 23 |
| West Plume | 37 | 92 | 100 | 41 | 8 | 16 | 11 | 11 | 46 | 3 | 0 | 14 |
| E. Brown's Pt. | 36 | 72 | 89 | 28 | 8 | 3 | 6 | 11 | 31 | 0 | 0 | 0 |
| W. Brown's Pt. | 35 | 97 | 97 | 9 | 31 | 14 | 9 | 0 | 29 | 0 | 0 | 14 |
| TOTAL | 182 | 84 | 95 | 45 | 20 | 13 | 27 | 6 | 33 | 3 | 10 | 17 |
| | | | | | | 1 9 8 1 | | | | | | |
| Peacock Pt. | 41 | 95 | 88 | 51 | 42 | 63 | 56 | 5 | 12 | 5 | 39 | 27 |
| Oneida | 44 | 70 | 86 | 48 | 30 | 61 | 34 | 2 | 14 | 16 | 0 | 43 |
| West Plume | 42 | 100 | 100 | 67 | 71 | 67 | 86 | 26 | 38 | 12 | 33 | 26 |
| E. Brown's Pt. | 43 | 65 | 77 | 5 | 2 | 9 | 2 | 12 | 19 | 2 | 2 | 2 |
| W. Brown's Pt. | 40 | 80 | 88 | 20 | 23 | 45 | 20 | 0 | 18 | 0 | 3 | 5 |
| TOTAL | 210 | 82 | 88 | 38 | 33 | 49 | 40 | 9 | 20 | 7 | 15 | 21 |
| | | | | | | 1 9 8 2 | | | | | | |
| Peacock Pt. | 50 | 96 | 96 | 40 | 36 | 32 | 60 | 2 | 2 | 0 | 42 | 28 |
| Oneida | 49 | 73 | 84 | 57 | 33 | 35 | 51 | 0 | 10 | 4 | 0 | 27 |
| West Plume | 50 | 100 | 100 | 52 | 62 | 40 | 56 | 22 | 34 | 0 | 18 | 16 |
| E. Brown's Pt. | 49 | 63 | 63 | 31 | 8 | 0 | 6 | 4 | 2 | 0 | 0 | 0 |
| W. Brown's Pt. | 47 | 89 | 94 | 9 | 13 | 19 | 4 | 0 | 4 | 0 | 2 | 2 |
| TOTAL | 245 | 84 | 87 | 38 | 31 | 25 | 36 | 6 | 11 | 1 | 13 | 15 |
| | | | | | | 1 9 8 3 | | | | | | |
| Peacock Pt. | 45 | 80 | 80 | 44 | 22 | 16 | 24 | 0 | 2 | 29 | 7 | 22 |
| Oneida | 46 | 80 | 63 | 61 | 22 | 11 | 35 | 2 | 4 | 41 | 2 | 28 |
| West Plume | 45 | 100 | 100 | 71 | 27 | 38 | 49 | 29 | 47 | [illegible] | 22 | 33 |
| E. Brown's Pt. | 44 | 70 | 32 | 48 | 2 | 0 | 2 | 9 | 5 | 9 | 0 | 5 |
| W. Brown's Pt. | 44 | 43 | 66 | 18 | 9 | 0 | 5 | 0 | 2 | 11 | 0 | 0 |
| TOTAL | 224 | 75 | 68 | 49 | 17 | 13 | 23 | 8 | 12 | 26 | 6 | 18 |

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[1] Sunfish = bluegill and pumpkinseed.
Crappie = black and white crappies.
Bullhead = brown and yellow bullheads.

Table 3.2.1-11. Percent of trap net lifts that caught fish (catch > 0) of a specified kind at standard Centre Creek locations by year and location (April - October).[1]

| | | SPECIES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOCATION | No. lifts | Rock bass | Yellow perch | FW. drum | Smallmouth bass | White bass | White sucker | Sunfish | Crappie | Gizzard shad | Bullhead | Quill-back |
| | | | | | | 1980 | | | | | | |
| E. Centre Ck. | 45 | 76 | 76 | 16 | 0 | 11 | 2 | 0 | 2 | 4 | 0 | 0 |
| W. Centre Ck. | 45 | 93 | 91 | 20 | 4 | 13 | 20 | 9 | 29 | 4 | 4 | 11 |
| TOTAL | 90 | 84 | 83 | 18 | 2 | 12 | 11 | 4 | 16 | 4 | 2 | 6 |
| | | | | | | 1981 | | | | | | |
| E. Centre Ck. | 45 | 73 | 69 | 16 | 0 | 24 | 9 | 7 | 11 | 0 | 9 | 2 |
| W. Centre Ck. | 39 | 54 | 74 | 8 | 3 | 18 | 3 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 84 | 64 | 71 | 12 | 1 | 21 | 6 | 4 | 6 | 0 | 5 | 1 |
| | | | | | | 1982 | | | | | | |
| E. Centre Ck. | 49 | 100 | 96 | 27 | 63 | 57 | 49 | 53 | 31 | 6 | 65 | 10 |
| W. Centre Ck. | 48 | 94 | 88 | 17 | 17 | 31 | 6 | 10 | 33 | 0 | 0 | 17 |
| TOTAL | 97 | 97 | 92 | 22 | 40 | 44 | 28 | 32 | 32 | 3 | 33 | 13 |
| | | | | | | 1983 | | | | | | |
| E. Centre Ck. | 43 | 84 | 86 | 40 | 12 | 21 | 26 | 28 | 19 | 23 | 5 | 19 |
| W. Centre Ck. | 44 | 95 | 89 | 36 | 59 | 48 | 30 | 39 | 30 | 9 | 25 | 18 |
| TOTAL | 87 | 90 | 87 | 38 | 36 | 34 | 28 | 33 | 24 | 16 | 15 | 18 |

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[1] Sunfish = bluegill and pumpkinseed,
Crappie = black and white crappies,
Bullhead = brown and yellow bullheads.

Table 3.2.1-12. Catch statistics of yellow perch, rock bass, and all fish taken in trap nets at Nanticoke by year, location and season (% C = percent composition).

| LOC[1] | SEA[2] | NO. LIFTS | YELLOW PERCH | | | ROCK BASS | | | ALL FISH | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | MEAN | SD | %C | MEAN | SD | %C | MEAN | SD |
| | | | | | 1971 | | | | | |
| SEL | LS | 1 | 0.0 | 0.00 | 0.0 | 1.0 | 0.00 | 4.8 | 21.0 | 0.00 |
| PEA | ES | 4 | 1.5 | 1.91 | 1.6 | 3.0 | 2.45 | 3.1 | 96.5 | 71.54 |
| | LS | 9 | 5.2 | 9.18 | 18.9 | 6.0 | 4.64 | 21.7 | 27.7 | 12.25 |
| | F | 4 | 2.0 | 2.31 | 3.6 | 1.8 | 1.71 | 3.2 | 55.3 | 53.28 |
| ONE | ES | 4 | 4.0 | 2.94 | 3.0 | 7.3 | 7.14 | 5.4 | 133.8 | 93.50 |
| | LS | 7 | 5.0 | 5.83 | 22.4 | 2.7 | 1.11 | 12.2 | 22.3 | 15.69 |
| | F | 4 | 13.3 | 26.50 | 20.3 | 2.0 | 1.15 | 3.1 | 65.3 | 50.00 |
| WBP | ES | 18 | 2.0 | 1.73 | 4.6 | 9.1 | 11.17 | 21.0 | 43.4 | 45.58 |
| | LS | 20 | 2.0 | 2.31 | 4.9 | 3.2 | 3.99 | 7.8 | 40.9 | 39.16 |
| | G | 21 | 1.4 | 2.26 | 4.1 | 4.1 | 4.93 | 11.8 | 34.4 | 22.61 |
| | | | | | 1972 | | | | | |
| SEL | S | 2 | 16.5 | 4.95 | 26.8 | 29.0 | 28.28 | 47.2 | 61.5 | 24.75 |
| | ES | 3 | 1.3 | 0.58 | 2.6 | 0.7 | 1.15 | 1.3 | 51.3 | 36.25 |
| | LS | 2 | 1.0 | 1.41 | 9.1 | 0.5 | 0.71 | 4.5 | 11.0 | 4.24 |
| | F | 2 | 0.5 | 0.71 | 2.5 | 1.0 | 1.41 | 5.0 | 20.0 | 1.41 |
| PEA | S | 14 | 17.5 | 30.88 | 41.7 | 9.5 | 10.11 | 22.6 | 42.0 | 41.55 |
| | ES | 7 | 1.0 | 1.15 | 2.2 | 1.4 | 1.13 | 3.2 | 44.7 | 53.64 |
| | LS | 4 | 2.0 | 2.31 | 44.4 | 0.3 | 0.50 | 5.6 | 4.5 | 2.89 |
| | F | 2 | 0.0 | 0.00 | 0.0 | 2.0 | 0.00 | 5.1 | 39.0 | 33.94 |
| WBP | S | 7 | 77.6 | 90.92 | 67.4 | 13.9 | 15.37 | 12.0 | 115.1 | 93.18 |
| | ES | 6 | 4.5 | 6.98 | 12.6 | 8.3 | 6.53 | 23.3 | 35.8 | 36.36 |
| | LS | 27 | 2.3 | 3.05 | 9.8 | 6.2 | 6.34 | 26.2 | 23.7 | 15.67 |
| | F | 6 | 0.3 | 0.82 | 0.6 | 5.7 | 7.06 | 9.4 | 60.0 | 39.06 |
| | | | | | 1973 | | | | | |
| SEL | LS | 2 | 1.0 | 1.41 | 22.2 | 0.0 | 0.00 | 0.0 | 4.5 | 2.12 |
| | F | 6 | 1.2 | 1.64 | 7.1 | 1.6 | 1.82 | 9.4 | 17.0 | 8.09 |
| PEA | LS | 6 | 3.0 | 4.24 | 37.5 | 2.5 | 3.54 | 31.3 | 8.0 | 11.31 |
| | F | 1 | 0.2 | 0.45 | 0.7 | 1.0 | 1.41 | 3.6 | 27.6 | 12.16 |
| ONE | LS | 3 | 1.5 | 2.12 | 15.0 | 1.0 | 1.41 | 10.0 | 10.0 | 5.66 |
| EBP | ES | 2 | 1.0 | 0.00 | 0.9 | 9.0 | 12.73 | 7.8 | 115.5 | 81.32 |
| | F | 24 | 4.8 | 4.44 | 23.1 | 6.0 | 2.74 | 28.8 | 20.8 | 11.37 |
| WBP | LS | 2 | 0.0 | 0.00 | 0.0 | 1.5 | 2.12 | 13.0 | 11.5 | 3.54 |
| | F | 5 | 0.6 | 0.89 | 4.8 | 0.6 | 1.34 | 4.8 | 12.6 | 14.43 |
| | | | | | 1974 | | | | | |
| SEL | S | 6 | 5.2 | 5.34 | 34.8 | 2.0 | 1.26 | 13.5 | 14.8 | 6.52 |
| | ES | 5 | 0.8 | 1.10 | 7.7 | 1.6 | 0.55 | 15.4 | 10.4 | 9.61 |
| ONE | S | 7 | 15.9 | 13.26 | 13.0 | 57.4 | 32.45 | 47.1 | 121.9 | 61.47 |
| | ES | 7 | 9.0 | 11.62 | 16.5 | 15.3 | 13.44 | 28.0 | 54.6 | 47.82 |
| | LS | 10 | 4.5 | 4.74 | 18.6 | 4.6 | 3.81 | 19.0 | 24.2 | 14.85 |
| | F | 13 | 3.3 | 2.46 | 18.1 | 3.8 | 5.60 | 21.0 | 18.3 | 15.07 |
| WPL | S | 8 | 95.6 | 59.98 | 51.6 | 62.3 | 31.04 | 33.6 | 185.3 | 96.97 |
| | ES | 8 | 16.4 | 9.26 | 25.1 | 36.6 | 29.89 | 56.1 | 65.3 | 47.36 |
| | LS | 10 | 12.6 | 8.98 | 24.7 | 9.4 | 8.87 | 18.4 | 51.1 | 18.74 |
| | F | 13 | 17.5 | 13.03 | 20.8 | 32.2 | 26.97 | 38.3 | 84.2 | 54.03 |
| WBP | S | 4 | 1.5 | 1.73 | 6.0 | 0.8 | 1.50 | 3.0 | 25.0 | 27.42 |
| | ES | 5 | 1.8 | 1.64 | 4.8 | 6.2 | 6.14 | 16.6 | 37.4 | 31.67 |
| | LS | 9 | 2.9 | 2.85 | 10.9 | 14.8 | 9.05 | 55.6 | 26.6 | 12.09 |
| | F | 14 | 1.0 | 1.04 | 3.6 | 16.6 | 12.07 | 60.5 | 27.5 | 16.37 |
| | | | | | 1975 | | | | | |
| SEL | LS | 8 | 1.4 | 1.06 | 4.4 | 1.8 | 1.49 | 5.6 | 31.3 | 20.55 |
| | F | 6 | 1.5 | 0.84 | 3.9 | 1.3 | 1.21 | 3.5 | 38.0 | 24.76 |
| PEA | S | 7 | 3.9 | 7.24 | 33.8 | 5.3 | 4.54 | 46.3 | 11.4 | 11.60 |
| | ES | 7 | 0.7 | 1.25 | 20.8 | 1.3 | 1.70 | 37.5 | 3.4 | 3.15 |
| | LS | 8 | 2.4 | 2.50 | 65.5 | 0.1 | 0.35 | 3.4 | 3.6 | 2.88 |
| | F | 6 | 3.0 | 2.19 | 25.0 | 4.0 | 2.61 | 33.3 | 12.0 | 5.10 |
| ONE | S | 9 | 10.3 | 6.50 | 21.3 | 20.4 | 14.45 | 42.2 | 48.4 | 28.32 |
| | ES | 9 | 2.6 | 1.51 | 7.8 | 13.3 | 12.19 | 40.5 | 32.9 | 21.25 |
| | LS | 8 | 1.0 | 0.93 | 12.1 | 0.5 | 0.76 | 6.1 | 8.3 | 9.47 |
| | F | 7 | 1.1 | 1.07 | 16.7 | 1.6 | 2.15 | 22.9 | 6.9 | 6.01 |
| WPL | S | 8 | 7.3 | 5.87 | 26.0 | 20.4 | 16.96 | 73.1 | 27.9 | 20.35 |
| | ES | 7 | 6.7 | 4.86 | 26.6 | 15.7 | 8.90 | 62.1 | 25.3 | 13.43 |
| | LS | 7 | 2.9 | 1.07 | 37.7 | 0.7 | 0.95 | 9.4 | 7.6 | 4.89 |
| | F | 6 | 2.2 | 1.33 | 65.0 | 0.7 | 0.82 | 20.0 | 3.3 | 2.94 |
| EBP | S | 9 | 3.9 | 2.80 | 54.7 | 2.2 | 3.90 | 31.3 | 7.1 | 6.23 |
| | ES | 9 | 2.0 | 1.50 | 31.6 | 3.6 | 3.84 | 56.1 | 6.3 | 3.57 |
| | LS | 8 | 9.8 | 5.47 | 37.1 | 3.8 | 2.31 | 14.3 | 26.3 | 9.44 |
| | F | 7 | 10.6 | 4.83 | 36.8 | 2.9 | 2.34 | 10.0 | 28.7 | 21.65 |
| WBP | S | 10 | 6.1 | 6.19 | 75.3 | 1.8 | 2.53 | 22.2 | 8.1 | 7.02 |
| | ES | 8 | 2.4 | 2.62 | 33.3 | 4.5 | 4.31 | 63.2 | 7.1 | 6.22 |
| | LS | 7 | 0.9 | 0.69 | 18.8 | 1.6 | 1.40 | 34.4 | 4.6 | 2.15 |
| | F | 5 | 1.6 | 1.52 | 26.7 | 1.6 | 1.52 | 26.7 | 6.0 | 4.24 |

Table 3.2.1-12 con't ....

| | | | YELLOW PERCH | | | ROCK BASS | | | ALL FISH | |
|---|---|---|---|---|---|---|---|---|---|---|
| LOC[1] | SEA[2] | NO. LIFTS | MEAN | SD | %C | MEAN | SD | %C | MEAN | SD |
| | | | | | 1976 | | | | | |
| SEL | S | 8 | 3.1 | 2.10 | 14.5 | 13.8 | 13.99 | 63.6 | 21.6 | 19.51 |
| | ES | 7 | 1.6 | 1.62 | 20.4 | 4.0 | 2.83 | 51.9 | 7.7 | 4.19 |
| | LS | 6 | 1.8 | 2.14 | 36.7 | 0.2 | 0.41 | 3.3 | 5.0 | 3.79 |
| | F | 9 | 4.6 | 3.32 | 40.6 | 1.4 | 1.88 | 12.9 | 11.2 | 5.19 |
| PEA | S | 7 | 9.6 | 10.57 | 24.5 | 21.4 | 23.14 | 54.9 | 39.0 | 29.52 |
| | ES | 5 | 2.2 | 1.92 | 22.4 | 5.2 | 5.12 | 53.1 | 9.8 | 8.64 |
| | LS | 7 | 8.1 | 7.43 | 70.4 | 0.9 | 1.86 | 7.4 | 11.6 | 8.58 |
| | F | 10 | 12.7 | 10.39 | 85.8 | 1.1 | 1.60 | 7.4 | 14.8 | 11.35 |
| ONE | S | 8 | 12.9 | 5.84 | 8.9 | 58.5 | 40.06 | 40.3 | 145.0 | 86.98 |
| | ES | 8 | 5.9 | 4.58 | 20.1 | 14.0 | 10.54 | 47.9 | 29.3 | 16.64 |
| | LS | 9 | 8.8 | 6.28 | 38.7 | 4.9 | 6.37 | 21.6 | 22.7 | 14.16 |
| | F | 9 | 11.4 | 8.08 | 42.0 | 8.6 | 5.88 | 31.4 | 27.2 | 17.73 |
| WPL | S | 11 | 20.3 | 12.81 | 32.4 | 30.9 | 23.18 | 49.4 | 62.5 | 35.65 |
| | ES | 8 | 1.5 | 1.60 | 7.1 | 15.9 | 17.39 | 74.7 | 21.3 | 19.65 |
| | LS | 10 | 1.2 | 1.40 | 9.3 | 2.9 | 2.77 | 22.5 | 12.9 | 6.14 |
| | F | 11 | 4.2 | 3.57 | 25.6 | 9.9 | 12.82 | 60.6 | 16.4 | 12.52 |
| EBP | S | 11 | 2.8 | 2.52 | 4.7 | 41.2 | 48.26 | 69.3 | 59.5 | 61.29 |
| | ES | 9 | 2.6 | 3.84 | 22.1 | 5.9 | 3.69 | 51.0 | 11.6 | 7.58 |
| | LS | 10 | 12.8 | 5.18 | 31.0 | 6.6 | 5.56 | 16.0 | 41.3 | 16.56 |
| | F | 11 | 7.5 | 7.17 | 21.7 | 14.6 | 16.57 | 42.6 | 34.4 | 24.30 |
| WBP | S | 10 | 2.7 | 4.08 | 12.9 | 14.9 | 16.81 | 71.3 | 20.9 | 23.98 |
| | ES | 8 | 0.9 | 0.99 | 15.6 | 4.5 | 4.81 | 80.0 | 5.6 | 4.81 |
| | LS | 10 | 1.3 | 1.16 | 18.1 | 4.4 | 2.91 | 61.1 | 7.2 | 4.66 |
| | F | 11 | 2.0 | 2.05 | 24.4 | 5.8 | 10.88 | 71.1 | 8.2 | 11.15 |
| | | | | | 1977 | | | | | |
| SEL | S | 6 | 9.2 | 7.88 | 43.3 | 8.8 | 7.36 | 41.7 | 21.7 | 15.69 |
| | ES | 6 | 1.3 | 2.34 | 21.1 | 3.8 | 1.94 | 60.5 | 6.3 | 3.44 |
| | LS | 7 | 2.9 | 1.68 | 16.1 | 1.7 | 1.60 | 9.7 | 17.7 | 17.53 |
| | F | 7 | 3.0 | 1.41 | 16.0 | 3.0 | 1.53 | 16.0 | 18.7 | 10.92 |
| PEA | S | 10 | 3.6 | 3.92 | 40.9 | 1.2 | 1.87 | 13.6 | 8.8 | 10.21 |
| | ES | 5 | 0.0 | 0.00 | 0.0 | 0.2 | 0.45 | 100.00 | 0.2 | 0.45 |
| | LS | 7 | 1.3 | 1.60 | 52.9 | 0.7 | 0.95 | 29.4 | 2.4 | 2.57 |
| | F | 6 | 1.7 | 1.90 | 47.6 | 0.7 | 0.82 | 19.0 | 3.5 | 2.26 |
| ONE | S | 11 | 11.5 | 5.97 | 20.9 | 26.2 | 22.08 | 47.4 | 55.2 | 36.14 |
| | ES | 12 | 9.8 | 11.12 | 39.5 | 4.2 | 5.62 | 16.7 | 24.9 | 29.16 |
| | LS | 11 | 6.8 | 2.23 | 38.9 | 1.8 | 2.36 | 10.4 | 17.5 | 10.63 |
| | F | 10 | 7.4 | 4.17 | 17.6 | 8.7 | 10.08 | 20.7 | 42.1 | 24.45 |
| | | | | | 1977 Cont'd | | | | | |
| WPL | S | 11 | 41.5 | 33.20 | 44.7 | 6.5 | 39.85 | 50.1 | 92.7 | 69.11 |
| | ES | 12 | 17.3 | 14.56 | 43.7 | 20.0 | 12.27 | 50.4 | 39.7 | 22.65 |
| | LS | 11 | 35.3 | 14.30 | 51.3 | 15.1 | 5.19 | 22.0 | 68.7 | 20.44 |
| | F | 10 | 35.0 | 14.76 | 35.7 | 40.2 | 24.21 | 41.0 | 98.1 | 25.97 |
| EBP | S | 11 | 13.5 | 11.61 | 35.6 | 17.0 | 21.35 | 44.6 | 38.1 | 36.27 |
| | ES | 12 | 5.7 | 4.46 | 61.3 | 2.2 | 3.46 | 23.4 | 9.3 | 8.25 |
| | LS | 10 | 8.7 | 4.74 | 40.7 | 3.6 | 2.27 | 16.8 | 21.4 | 8.92 |
| | F. | 9 | 11.1 | 6.25 | 47.4 | 5.0 | 5.81 | 21.3 | 23.4 | 15.10 |
| WBP | S | 12 | 7.8 | 9.10 | 15.4 | 40.1 | 51.95 | 78.9 | 50.8 | 62.08 |
| | ES | 12 | 1.8 | 1.59 | 11.6 | 13.0 | 13.07 | 82.5 | 15.8 | 13.55 |
| | LS | 9 | 4.4 | 5.34 | 24.2 | 7.6 | 7.45 | 41.2 | 18.3 | 12.78 |
| | F | 8 | 5.5 | 2.73 | 34.1 | 7.5 | 7.67 | 46.5 | 16.1 | 6.92 |
| | | | | | 1978 | | | | | |
| SEL | S | 7 | 4.6 | 2.57 | 35.2 | 5.6 | 7.57 | 42.9 | 13.0 | 11.42 |
| | ES | 9 | 1.4 | 1.51 | 41.9 | 1.2 | 1.72 | 35.5 | 3.4 | 1.81 |
| | LS | 8 | 2.1 | 1.64 | 24.3 | 0.6 | 0.74 | 7.1 | 8.8 | 4.20 |
| | F | 11 | 3.3 | 4.82 | 22.5 | 0.8 | 1.08 | 5.6 | 14.5 | 8.36 |
| PEA | S | 6 | 27.5 | 15.19 | 55.9 | 2.8 | 3.71 | 5.8 | 49.2 | 43.95 |
| | ES | 8 | 2.6 | 2.88 | 47.7 | 1.6 | 1.51 | 29.5 | 5.5 | 4.50 |
| | LS | 7 | 3.0 | 2.16 | 34.4 | 1.1 | 0.90 | 13.1 | 8.7 | 9.74 |
| | F | 6 | 8.0 | 3.29 | 55.2 | 2.3 | 1.21 | 16.1 | 14.5 | 5.47 |
| ONE | S | 7 | 8.0 | 4.04 | 5.7 | 82.6 | 76.15 | 58.4 | 141.3 | 115.70 |
| | ES | 8 | 3.3 | 1.75 | 21.0 | 4.5 | 4.74 | 29.0 | 15.5 | 8.18 |
| | LS | 11 | 5.5 | 3.59 | 19.7 | 2.9 | 2.74 | 10.4 | 28.1 | 10.71 |
| | F | 7 | 3.9 | 1.86 | 17.1 | 2.0 | 1.83 | 8.9 | 22.6 | 9.66 |
| WPL | S | 4 | 20.5 | 35.03 | 34.5 | 35.5 | 24.45 | 59.7 | 59.5 | 52.18 |
| | ES | 9 | 1.7 | 2.06 | 9.4 | 14.6 | 17.28 | 81.9 | 17.8 | 18.96 |
| | LS | 10 | 3.8 | 2.97 | 16.5 | 5.3 | 3.40 | 23.0 | 23.0 | 18.27 |
| | F | 5 | 17.4 | 19.01 | 28.3 | 15.4 | 13.07 | 25.1 | 61.4 | 21.26 |
| EBP | S | 7 | 6.4 | 4.12 | 31.7 | 9.6 | 22.79 | 47.2 | 20.3 | 30.91 |
| | ES | 8 | 0.5 | 0.53 | 23.5 | 1.5 | 2.83 | 70.6 | 2.1 | 3.27 |
| | LS | 9 | 1.6 | 1.59 | 25.0 | 2.2 | 1.79 | 35.7 | 6.2 | 4.58 |
| | F | 7 | 3.6 | 4.12 | 28.4 | 3.9 | 5.34 | 30.7 | 12.6 | 6.92 |
| WBP | S | 7 | 60.0 | 20.82 | 39.9 | 84.4 | 74.07 | 56.2 | 150.3 | 91.21 |
| | ES | 8 | 20.5 | 11.03 | 46.5 | 21.9 | 26.85 | 49.6 | 44.1 | 27.37 |
| | LS | 10 | 13.8 | 8.03 | 30.8 | 25.3 | 20.55 | 56.5 | 44.8 | 25.18 |
| | F | 7 | 4.6 | 4.86 | 13.3 | 13.9 | 10.33 | 40.4 | 34.3 | 17.22 |

Table 3.2.1-12. con't ....

| LOC[1] | SEA[2] | NO. LIFTS | YELLOW PERCH MEAN | YELLOW PERCH SD | YELLOW PERCH %C | ROCK BASS MEAN | ROCK BASS SD | ROCK BASS %C | ALL FISH MEAN | ALL FISH SD |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1980 | | | | | |
| SEI | S | [illegible] | 4.6 | 2.57 | 35.2 | 5.6 | 7.57 | 42.9 | 13.0 | 11.42 |
| | ES | 4 | 1.4 | 1.51 | 41.9 | 1.2 | 1.72 | 35.5 | 3.4 | 1.81 |
| | LS | 4 | 2.1 | 1.64 | 24.1 | 0.6 | 0.74 | 7.1 | 8.8 | 4.20 |
| | F | 11 | 3.3 | 4.82 | 22.5 | 0.8 | 1.08 | 5.6 | 14.5 | 8.36 |
| PEA | S | [illegible] | 45.[illegible] | 16.24 | 49.0 | 36.5 | 24.91 | 39.7 | 91.8 | 25.38 |
| | ES | 3 | 7.0 | 7.16 | 23.8 | 19.2 | 16.22 | 65.3 | 29.4 | 21.15 |
| | LS | 3 | 3.1 | 2.92 | 13.1 | 7.9 | 8.51 | 20.2 | 39.1 | 18.80 |
| | F | 11 | 13.1 | 14.07 | 28.1 | 5.3 | 3.07 | 11.4 | 46.2 | 24.41 |
| ONE | S | [illegible] | 6.7 | 4.82 | 11.5 | 9.3 | 8.40 | 16.0 | 58.1 | 27.21 |
| | ES | 10 | 4.9 | 4.09 | 42.2 | 1.7 | 1.42 | 14.7 | 11.6 | 5.48 |
| | LS | 9 | 6.0 | 3.12 | 73.0 | 0.4 | 0.51 | 5.4 | 8.2 | 3.19 |
| | F | 13 | 4.5 | 5.77 | 32.6 | 4.3 | 5.31 | 31.7 | 13.5 | 10.10 |
| WPL | S | [illegible] | 22.1 | 16.95 | 52.7 | 17.0 | 17.19 | 40.5 | 42.0 | 28.27 |
| | ES | 10 | 3.7 | 1.70 | 37.4 | 4.5 | 1.44 | 45.5 | 9.9 | 3.93 |
| | LS | 4 | 11.5 | 6.91 | 56.4 | 4.8 | 2.82 | 23.3 | 20.4 | 9.80 |
| | F | 12 | 23.6 | 24.86 | 58.0 | 10.3 | 6.02 | 25.4 | 40.7 | 27.12 |
| EBP | S | [illegible] | 2.6 | 1.29 | 20.3 | 5.1 | 7.47 | 51.7 | 9.6 | 7.32 |
| | ES | 10 | 2.1 | 1.74 | 36.2 | 2.8 | 1.53 | 48.3 | 5.8 | 3.36 |
| | LS | [illegible] | 1.3 | 0.76 | 17.6 | 3.3 | 4.07 | 72.5 | 7.3 | 4.50 |
| | F | 12 | 1.0 | 4.33 | 27.1 | 2.3 | 2.15 | 21.1 | 11.1 | 6.60 |
| WBP | S | [illegible] | 19.1 | 3.28 | 58.7 | 8.1 | 6.92 | 29.7 | 27.9 | 3.56 |
| | ES | [illegible] | 14.7 | 5.77 | 57.1 | 10.3 | 9.94 | 40.3 | 25.7 | 8.51 |
| | LS | [illegible] | 18.9 | 12.46 | 41.3 | 22.1 | 17.23 | 30.8 | 43.6 | 29.39 |
| | F | 12 | 11.3 | 4.41 | 57.2 | 4.9 | 2.94 | 25.0 | 19.7 | 10.65 |
| | | | | | 1981 | | | | | |
| SEI | S | [illegible] | 5.0 | 1.41 | 50.0 | 0.8 | 1.10 | 13.3 | 6.0 | 2.55 |
| | ES | 1 | 1.0 | - | 50.0 | 1.0 | - | 50.0 | 2.0 | - |
| PEA | S | 7 | 34.9 | 25.57 | 52.7 | 21.2 | 8.07 | 32.2 | 65.6 | 32.61 |
| | ES | 12 | 1.8 | 2.04 | 13.7 | 10.3 | 11.67 | 77.0 | 13.4 | 12.83 |
| | LS | 12 | 5.1 | 5.73 | 20.1 | 4.1 | 2.61 | 16.1 | 25.1 | 16.57 |
| | F | 10 | 26.0 | 21.21 | 36.3 | 9.8 | 7.57 | 13.7 | 71.7 | 26.13 |
| ONE | S | 8 | 8.9 | 7.49 | 37.6 | 2.1 | 1.96 | 9.0 | 23.6 | 14.91 |
| | ES | 13 | 1.5 | 1.71 | 35.2 | 1.5 | 1.81 | 37.0 | 4.2 | 4.08 |
| | LS | 11 | 7.0 | 4.65 | 22.4 | 1.6 | 1.75 | 5.2 | 31.2 | 26.60 |
| | F | 12 | 7.4 | 4.38 | 16.8 | 4.7 | 6.20 | 10.6 | 44.2 | 53.88 |
| WPL | S | [illegible] | 36.8 | 33.56 | 43.1 | 57.1 | 28.46 | 41.5 | 131.3 | 59.95 |
| | ES | 14 | 21.5 | 19.23 | 33.5 | 14.6 | 12.99 | 53.9 | 64.1 | 24.14 |
| | LS | 11 | 42.5 | 14.12 | 42.7 | 16.7 | 4.82 | 16.8 | 99.7 | 44.40 |
| | F | 10 | 70.9 | 29.05 | 41.2 | 65.3 | 30.49 | 38.3 | 172.1 | 57.43 |
| EBP | S | [illegible] | 1.4 | 1.51 | 41.5 | 26.6 | 29.62 | 39.3 | 66.6 | 25.91 |
| | ES | 13 | 1.1 | 1.19 | 50.0 | 27.1 | 23.14 | 64.4 | 42.1 | 27.26 |
| | LS | 11 | 1.4 | 0.92 | 16.7 | 12.1 | 5.94 | 37.8 | 32.0 | 30.62 |
| | F | 12 | 4.5 | 3.45 | 34.0 | 0.5 | 1.08 | 7.7 | 6.5 | 9.51 |
| WBP | S | 7 | 31.1 | 15.33 | 46.8 | 26.6 | 29.62 | 39.9 | 66.0 | 25.91 |
| | ES | [illegible] | 14.0 | 11.68 | 33.3 | 27.1 | 23.14 | 64.4 | 42.1 | 27.26 |
| | LS | 11 | 7.6 | 5.68 | 23.9 | 12.1 | 5.94 | 37.8 | 32.0 | 30.62 |
| | F | 12 | 2.0 | 2.49 | 30.8 | 0.5 | 1.08 | 7.7 | 6.5 | 9.51 |

| LOC[1] | SEA[2] | NO. LIFTS | YELLOW PERCH MEAN | YELLOW PERCH SD | YELLOW PERCH %C | ROCK BASS MEAN | ROCK BASS SD | ROCK BASS %C | ALL FISH MEAN | ALL FISH %C |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1982 | | | | | |
| PEA | S | 9 | 12.1 | 11.03 | 29.1 | 18.0 | 14.40 | 43.2 | 41.7 | 26.72 |
| | ES | 14 | 4.4 | 4.16 | 18.8 | 16.1 | 8.53 | 69.8 | 23.1 | 8.67 |
| | LS | 12 | 9.3 | 5.31 | 35.7 | 4.9 | 2.94 | 19.0 | 25.9 | 15.23 |
| | F | 15 | 8.5 | 6.49 | 28.5 | 6.4 | 5.67 | 21.6 | 29.7 | 22.46 |
| ONE | S | 9 | 17.3 | 17.97 | 30.6 | 23.9 | 18.61 | 42.2 | 56.7 | 43.02 |
| | ES | 14 | 2.3 | 3.32 | 43.2 | 1.6 | 2.44 | 29.7 | 5.3 | 7.18 |
| | LS | 12 | 8.3 | 5.91 | 39.5 | 2.9 | 2.97 | 13.8 | 21.1 | 16.74 |
| | F | 14 | 3.7 | 3.85 | 17.6 | 4.6 | 7.01 | 21.6 | 23.1 | 28.55 |
| WPL | S | 9 | 131.7 | 121.66 | 69.7 | 42.9 | 29.46 | 22.7 | 189.0 | 144.70 |
| | ES | 14 | 33.9 | 16.65 | 46.1 | 30.1 | 15.15 | 40.9 | 73.6 | 25.55 |
| | LS | 12 | 20.5 | 10.33 | 51.6 | 7.8 | 4.37 | 19.7 | 39.8 | 13.51 |
| | F | 15 | 7.9 | 7.50 | 29.8 | 6.0 | 3.16 | 22.7 | 26.4 | 24.47 |
| EPL | S | 9 | 7.2 | 8.97 | 14.5 | 34.4 | 29.43 | 69.2 | 49.8 | 45.23 |
| | ES | 14 | 1.7 | 4.43 | 14.9 | 8.1 | 6.63 | 70.2 | 11.5 | 8.44 |
| | LS | 12 | 3.2 | 2.04 | 48.1 | 1.3 | 1.48 | 19.0 | 6.6 | 5.84 |
| | F | 14 | 5.4 | 4.25 | 58.6 | 2.6 | 2.92 | 28.9 | 9.1 | 7.00 |
| EBP | S | 9 | 1.2 | 1.20 | 25.0 | 1.9 | 2.71 | 38.6 | 4.9 | 2.47 |
| | ES | 14 | 0.5 | 0.65 | 15.9 | 2.2 | 2.33 | 70.5 | 3.1 | 2.57 |
| | LS | 12 | 0.9 | 1.24 | 18.3 | 3.7 | 4.29 | 73.3 | 5.0 | 4.37 |
| | F | 14 | 2.2 | 1.58 | 54.4 | 0.7 | 0.99 | 17.5 | 4.1 | 2.37 |
| WBP | S | 8 | 18.0 | 21.82 | 71.6 | 6.0 | 8.67 | 23.9 | 25.1 | 23.01 |
| | ES | 14 | 4.7 | 2.87 | 60.6 | 2.9 | 2.28 | 36.7 | 7.8 | 2.91 |
| | LS | 12 | 6.3 | 4.94 | 40.4 | 8.5 | 7.03 | 54.3 | 15.7 | 11.63 |
| | F | 13 | 5.0 | 4.78 | 50.0 | 3.6 | 3.18 | 36.2 | 10.0 | 6.01 |
| | | | | | 1983 | | | | | |
| PEA | S | 9 | 19.0 | 10.65 | 21.2 | 58.6 | 61.22 | 65.2 | 89.8 | 74.08 |
| | ES | 12 | 3.1 | 4.66 | 31.6 | 5.0 | 3.81 | 51.3 | 9.8 | 9.02 |
| | LS | 11 | 5.0 | 6.69 | 30.1 | 1.4 | 1.21 | 8.2 | 16.6 | 15.13 |
| | F | 13 | 2.2 | 1.95 | 31.8 | 1.5 | 1.45 | 21.6 | 6.8 | 6.85 |
| ONE | S | 9 | 6.9 | 4.01 | 9.0 | 35.9 | 40.05 | 47.0 | 76.3 | 74.15 |
| | ES | 12 | 1.2 | 1.85 | 17.5 | 2.9 | 3.37 | 43.8 | 6.7 | 6.96 |
| | LS | 11 | 1.4 | 1.43 | 7.6 | 3.1 | 4.41 | 17.2 | 18.0 | 22.22 |
| | F | 14 | 0.9 | 1.07 | 7.6 | 2.9 | 2.92 | 24.1 | 12.1 | 10.09 |
| WPI | S | 10 | 46.1 | 25.15 | 26.1 | 107.3 | 129.79 | 60.7 | 176.9 | 148.54 |
| | ES | 12 | 15.1 | 10.70 | 46.4 | 12.1 | 5.84 | 37.2 | 32.5 | 15.97 |
| | LS | 10 | 12.7 | 6.78 | 21.3 | 6.6 | 4.48 | 11.1 | 59.7 | 40.33 |
| | F | 13 | 27.7 | 26.29 | 27.9 | 18.5 | 14.25 | 18.6 | 99.2 | 40.70 |
| EPL | S | 10 | 2.4 | 2.32 | 3.9 | 42.2 | 53.76 | 68.5 | 61.6 | 75.36 |
| | ES | 12 | 0.2 | 2.17 | 2.9 | 4.6 | 1.68 | 79.7 | 5.8 | 2.83 |
| | LS | 10 | 1.9 | 0.39 | 13.9 | 3.8 | 1.99 | 27.7 | 13.7 | 7.20 |
| | F | 13 | 2.2 | 1.66 | 12.4 | 8.8 | 6.06 | 48.7 | 18.0 | 9.43 |
| EBP | S | 9 | 0.8 | 1.30 | 4.9 | 9.8 | 18.47 | 62.0 | 15.8 | 22.63 |
| | ES | 11 | 0.4 | 0.50 | 6.3 | 4.1 | 3.81 | 70.3 | 5.8 | 4.14 |
| | LS | 10 | 0.4 | 0.70 | 9.3 | 2.1 | 1.66 | 48.8 | 4.3 | 1.49 |
| | F | 13 | 0.5 | 0.97 | 9.7 | 3.4 | 8.41 | 61.1 | 5.5 | 10.32 |
| WBP | S | 9 | 4.3 | 2.29 | 19.8 | 15.6 | 30.83 | 71.1 | 21.9 | 33.81 |
| | ES | 12 | 1.8 | 2.62 | 75.9 | 0.6 | 0.79 | 24.1 | 21.4 | 2.35 |
| | LS | 10 | 2.1 | 2.28 | 48.8 | 1.2 | 1.87 | 27.9 | 4.3 | 2.71 |
| | F | 13 | 0.8 | 1.01 | 23.8 | 1.8 | 3.35 | 54.8 | 3.2 | 3.75 |

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[1] Locations: SEI = [illegible]
PEA = [illegible] Point
ONE = [illegible]
EPL = East Plume
WPL = West Plume
EBP = East Brown's Point
WBP = West Brown's Point

[2] Seasons: S = Spring
ES = Early Summer
LS = Late Summer
F = Fall

Table 3.2.1-13. Catch statistics of yellow perch, rock bass, and all fish taken in trap nets at Centre Creek by year, location and season (% C = percent composition).

| | | | YELLOW PERCH | | | ROCK BASS | | | ALL FISH | |
|---|---|---|---|---|---|---|---|---|---|---|
| LOC[1] | SEA[2] | NO. LIFTS | MEAN | SD | %C | MEAN | SD | %C | MEAN | SD |
| | | | | | 1980 | | | | | |
| ECK | S | 9 | 9.0 | 7.55 | 69.8 | 2.8 | 3.56 | 21.6 | 12.9 | 6.90 |
| | ES | 12 | 7.6 | 5.21 | 68.9 | 3.4 | 2.94 | 31.1 | 11.0 | 6.42 |
| | LS | 10 | 21.5 | 12.42 | 91.1 | 1.4 | 0.97 | 5.9 | 23.6 | 11.87 |
| | F | 14 | 1.1 | 2.56 | 12.1 | 1.2 | 1.63 | 13.7 | 8.9 | 12.66 |
| WCK | S | 9 | 31.7 | 34.67 | 32.6 | 60.7 | 39.56 | 62.5 | 97.0 | 42.12 |
| | ES | 12 | 22.8 | 22.28 | 56.6 | 16.9 | 12.46 | 41.9 | 40.3 | 31.96 |
| | LS | 10 | 25.9 | 13.08 | 76.4 | 6.4 | 4.88 | 18.9 | 33.9 | 15.34 |
| | F | 14 | 3.1 | 2.67 | 11.2 | 5.5 | 3.80 | 20.0 | 27.5 | 25.58 |
| | | | | | 1981 | | | | | |
| ECK | S | 8 | 9.6 | 7.52 | 24.6 | 4.5 | 6.02 | 11.5 | 39.1 | 30.34 |
| | ES | 14 | 2.5 | 3.48 | 26.9 | 6.1 | 8.75 | 65.4 | 9.3 | 11.62 |
| | LS | 10 | 1.8 | 1.48 | 27.3 | 2.8 | 2.49 | 42.4 | 6.6 | 4.09 |
| | F | 13 | 0.8 | 1.46 | 12.2 | 1.8 | 1.48 | 25.6 | 6.9 | 8.12 |
| WCK | S | 8 | 14.3 | 11.18 | 73.5 | 1.6 | 1.92 | 8.4 | 19.4 | 10.60 |
| | ES | 14 | 3.6 | 3.95 | 60.0 | 1.9 | 2.81 | 31.8 | 6.1 | 6.60 |
| | LS | 6 | 1.8 | 1.60 | 34.4 | 1.7 | 1.86 | 31.3 | 5.3 | 3.83 |
| | F | 11 | 1.7 | 2.33 | 44.2 | 2.1 | 3.24 | 53.5 | 3.9 | 4.50 |
| | | | | | 1982 | | | | | |
| ECK | S | 8 | 118.5 | 119.78 | 33.3 | 209.5 | 127.11 | 58.8 | 356.0 | 203.10 |
| | ES | 14 | 35.3 | 21.65 | 35.0 | 57.4 | 39.70 | 56.8 | 100.9 | 56.36 |
| | LS | 12 | 18.3 | 28.12 | 34.4 | 18.3 | 10.39 | 34.4 | 53.0 | 34.26 |
| | F | 15 | 6.2 | 5.99 | 13.0 | 10.3 | 7.61 | 21.5 | 47.8 | 52.39 |
| MCK | S | 7 | 46.1 | 58.00 | 68.7 | 14.1 | 18.32 | 21.1 | 67.1 | 61.58 |
| | ES | 14 | 13.4 | 13.80 | 75.8 | 2.4 | 2.21 | 13.7 | 17.7 | 16.20 |
| | LS | 12 | 3.5 | 4.54 | 19.7 | 1.8 | 1.70 | 10.3 | 17.8 | 25.52 |
| | F | 15 | 0.3 | 0.46 | 4.6 | 1.5 | 2.33 | 25.3 | 5.8 | 6.57 |
| WCK | S | 8 | 20.4 | 10.73 | 51.9 | 16.3 | 12.07 | 41.4 | 39.3 | 10.15 |
| | ES | 13 | 53.2 | 59.79 | 74.4 | 13.2 | 12.85 | 18.5 | 71.5 | 57.33 |
| | LS | 12 | 8.3 | 6.34 | 57.5 | 3.0 | 2.21 | 20.7 | 14.5 | 5.66 |
| | F | 15 | 1.5 | 2.00 | 12.7 | 2.9 | 3.85 | 24.9 | 11.5 | 9.96 |
| | | | | | 1983 | | | | | |
| ECK | S | 9 | 17.1 | 19.03 | 20.8 | 53.7 | 77.19 | 65.4 | 82.1 | 74.36 |
| | ES | 13 | 12.2 | 11.47 | 51.8 | 7.2 | 7.08 | 30.8 | 23.5 | 16.39 |
| | LS | 9 | 8.8 | 11.05 | 54.9 | 1.8 | 1.56 | 11.1 | 16.0 | 13.41 |
| | F | 12 | 4.8 | 5.27 | 23.5 | 7.4 | 7.98 | 36.0 | 20.6 | 15.04 |
| WCK | S | 9 | 29.9 | 25.31 | 18.1 | 106.1 | 124.50 | 64.2 | 165.2 | 148.49 |
| | ES | 13 | 24.8 | 31.67 | 30.2 | 47.2 | 25.86 | 57.3 | 82.2 | 55.97 |
| | LS | 10 | 3.1 | 3.28 | 13.7 | 10.7 | 8.38 | 47.3 | 22.6 | 14.21 |
| | F | 12 | 3.3 | 5.47 | 11.4 | 9.5 | 8.38 | 32.5 | 29.3 | 17.42 |

[1] Location:
ECK = East Centre Creek
WCK = West Centre Creek
MCK = Mid Centre Creek

[2] Season:
S = Spring
ES = Early Summer
LS = Late Summer
F = Fall

Table 3.2.1-14. Analysis of variance of log-transformed ($\log_{10} x + 1$) catches of rock bass and yellow perch in Nanticoke (1975-1983) and Centre Creek (1980-1983) trap nets.

| Source of Variation | df | ROCK BASS |  |  | YELLOW PERCH |  |  |
|---|---|---|---|---|---|---|---|
|  |  | SS | F | P | SS | F | P |
|  |  |  | NANTICOKE TRAP NETS |  |  |  |  |
| Year | 7 | 12.41 | 12.90 | 0.0001 | 22.70 | 32.88 | 0.0001 |
| Season | 3 | 41.80 | 101.41 | 0.0001 | 31.80 | 107.47 | 0.0001 |
| Location | 4 | 54.29 | 98.79 | 0.0001 | 54.42 | 137.91 | 0.0001 |
| YR * SEA | 21 | 13.25 | 4.59 | 0.0001 | 8.15 | 3.93 | 0.0001 |
| YR * LOC | 28 | 80.30 | 20.87 | 0.0001 | 82.42 | 29.84 | 0.0001 |
| SEA * LOC | 12 | 23.13 | 14.03 | 0.0001 | 12.97 | 10.96 | 0.0001 |
| YR * SEA * LOC | 84 | 36.73 | 3.18 | 0.0001 | 34.07 | 4.11 | 0.0001 |
| Model (explained) | 159 | 269.68 | 12.35 | 0.0001 | 253.59 | 16.17 | 0.0001 |
| Error (residual) | 1386 | 190.41 |  |  | 136.72 |  |  |
| Total | 1545 | 460.09 |  |  | 390.32 |  |  |
|  |  |  | CENTRE CREEK TRAP NETS |  |  |  |  |
| Year | 3 | 27.69 | 65.09 | 0.0001 | 17.04 | 39.79 | 0.0001 |
| Season | 3 | 18.34 | 43.10 | 0.0001 | 32.48 | 75.84 | 0.0001 |
| Location | 1 | 0.40 | 2.82 | 0.0941 | 0.08 | 0.56 | 0.4558 |
| YR * SEA | 9 | 6.09 | 4.77 | 0.0001 | 11.56 | 9.00 | 0.0001 |
| YR * LOC | 3 | 29.09 | 68.37 | 0.0001 | 4.17 | 9.73 | 0.0001 |
| SEA * LOC | 3 | 0.31 | 0.73 | 0.5404 | 0.98 | 2.30 | 0.0760 |
| YR * SEA * LOC | 9 | 5.29 | 4.15 | 0.0001 | 1.77 | 1.37 | 0.1981 |
| Model (explained) | 31 | 85.25 | 19.39 | 0.0001 | 68.64 | 15.51 | 0.0001 |
| Error (residual) | 326 | 46.23 |  |  | 46.54 |  |  |
| Total | 357 | 131.48 |  |  | 115.19 |  |  |

Table 3.2.1-15. Analysis of variance of log-transformed (log x + 1) catches of rock bass and yellow perch near the heated outfall of the Nanticoke TGS, 1982-1983.

| Source of Variation | df | ROCK BASS |  |  | YELLOW PERCH |  |  |
|---|---|---|---|---|---|---|---|
|  |  | SS | F | P | SS | F | P |
| Year | 1 | 0.25 | 2.37 | 0.1258 | 1.27 | 11.52 | 0.0009 |
| Season | 3 | 15.58 | 49.47 | 0.0001 | 4.51 | 13.61 | 0.0001 |
| Location | 1 | 6.62 | 63.07 | 0.0001 | 37.08 | 335.71 | 0.0001 |
| YR * SEA | 3 | 3.00 | 9.52 | 0.0001 | 1.10 | 3.32 | 0.0210 |
| YR * LOC | 1 | 0.10 | 0.99 | 0.3212 | 0.17 | 1.49 | 0.2232 |
| SEA * LOC | 3 | 0.18 | 0.59 | 0.6282 | 3.79 | 11.45 | 0.0001 |
| YR * SEA * LOC | 3 | 0.93 | 2.96 | 0.0335 | 1.94 | 5.87 | 0.0009 |
| Model (explained) | 15 | 27.73 | 17.61 | 0.0001 | 48.84 | 29.84 | 0.0001 |
| Error (Residual) | 173 | 18.16 |  |  | 19.11 |  |  |
| Total | 188 | 45.89 |  |  | 67.95 |  |  |

Table 3.2.1-16. Chi-square statistics (from logit analysis) testing the significance of year and location on dichotomized (present vs absent) catches of incidental species in Nanticoke (A) and Centre Creek (B) trapnets.

| A. | Two Factor Model[1] | | | | | Two Factor Model[2] | | | One Factor Model[3] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Source of Variation | df | Fw. drum | Sm. bass | White sucker | Crappie | df | White bass | Quill-back | df | Gizzard shad | Sunfish | Bullhead |
| Year | 7 | 13.75 | 17.24$^{+}$ | 16.76$^{+}$ | 59.58$^{*}$ | 7 | 140.43$^{*}$ | 12.92 | 7 | 97.40$^{*}$ | 21.97$^{+}$ | 21.52$^{+}$ |
| Location | 4 | 161.77$^{*}$ | 45.53$^{*}$ | 120.86$^{*}$ | 98.23$^{*}$ | 3 | 23.74$^{*}$ | 79.32$^{*}$ | | | | |
| YR x LOC | 28 | 98.71$^{*}$ | 124.98$^{*}$ | 153.51$^{*}$ | 65.86$^{*}$ | 21 | 60.52 | 37.07$^{+}$ | | | | |

| B. | Two Factor Model[1] | | | | | One Factor Model[4] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Source of Variation | df | Fw. drum | White bass | White sucker | Crappie | df | Sm. bass | Quill-back | Gizzard shad | Sunfish | Bullhead |
| Year | 3 | 17.85$^{*}$ | 23.48$^{*}$ | 15.72$^{*}$ | 15.91$^{+}$ | 3 | 34.64$^{*}$ | 12.54$^{+}$ | 14.97$^{+}$ | 34.42$^{*}$ | 32.33$^{*}$ |
| Location | 1 | 1.14 | 0.00 | 0.61 | 0.47 | | | | | | |
| YR x LOC | 3 | 2.08 | 13.53$^{+}$ | 20.59$^{*}$ | 9.19$^{+}$ | | | | | | |

[1] Seasons pooled (April 1 - October 31)

[2] Seasons pooled (April 1 - October 31); East and West Brown's Point combined

[3] Seasons pooled (April 1 - October 31); locations pooled (Peacock Pt., Oneida, West Plume, East Brown's Pt., West Brown's Pt.)

[4] Seasons pooled (April 1 - October 31); locations pooled (East and West Centre Creek)

$^{+}$ P = 0.05

$^{*}$ P = 0.001

$^{**}$ P = 0.0001

Table 3.2.1-17. Mean No. per lift (± SD) of the principal species and species pairs caught in trap nets at standard Nanticoke locations, 1975-1983 (April - October).[1]

| Summary Variable | No. Lifts | Statistic | Rock Bass | Yellow Perch | FW. Drum | Sm. Bass | White Bass | White Sucker | Sunfish | Crappie | Gizz. Shad | Bull-head | Quill-back |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOCATION | | | | | | | | | | | | | |
| Peacock Point | 284 | Mean | 8.6 | 8.6 | 1.3 | 0.5 | 1.1 | 2.1 | <0.1 | 0.2 | 0.3 | 1.2 | 0.7 |
| | | ± SD | 17.3 | 12.5 | 3.0 | 1.4 | 5.1 | 5.2 | 0.2 | 0.6 | 1.7 | 3.8 | 2.7 |
| Oneida | 323 | Mean | 9.8 | 6.0 | 6.0 | 1.2 | 2.5 | 2.2 | <0.1 | 0.2 | 0.8 | 0.1 | 0.8 |
| | | ± SD | 21.9 | 6.5 | 13.3 | 3.8 | 9.9 | 5.4 | 0.2 | 0.6 | 2.6 | 0.3 | 1.8 |
| West Plume | 315 | Mean | 22.9 | 24.5 | 2.2 | 1.2 | 1.8 | 1.0 | 0.4 | 1.9 | 0.7 | 0.5 | 0.4 |
| | | ± SD | 34.9 | 35.3 | 5.2 | 2.8 | 6.7 | 1.7 | 1.1 | 4.1 | 3.5 | 1.2 | 1.4 |
| East Brown's | 320 | Mean | 5.8 | 3.8 | 1.2 | 0.2 | 0.3 | 0.1 | 0.4 | 1.8 | <0.1 | 0.1 | 0.1 |
| | | ± SD | 13.7 | 5.3 | 3.8 | 0.7 | 1.0 | 0.6 | 1.5 | 4.9 | 0.1 | 0.4 | 0.5 |
| West Brown's | 309 | Mean | 11.9 | 8.4 | 0.3 | 0.6 | 0.8 | 0.2 | <0.1 | 0.3 | <0.1 | <0.1 | 0.1 |
| | | ± SD | 23.5 | 12.6 | 0.9 | 1.7 | 5.1 | 0.7 | 0.2 | 1.3 | 0.1 | 0.3 | 0.3 |
| SEASON | | | | | | | | | | | | | |
| Spring | 336 | Mean | 27.1 | 18.6 | 6.2 | 1.0 | 1.7 | 1.6 | <0.1 | 0.2 | 0.1 | 0.1 | 0.1 |
| | | ± SD | 43.0 | 33.0 | 13.7 | 3.6 | 6.3 | 4.2 | 0.2 | 0.5 | 0.8 | 0.4 | 0.5 |
| Early Summer | 414 | Mean | 8.3 | 6.2 | 1.2 | 0.4 | 0.2 | 0.6 | <0.1 | 0.1 | <0.1 | <0.1 | <0.1 |
| | | ± SD | 13.0 | 10.2 | 2.9 | 1.6 | 0.7 | 1.6 | 0.1 | 0.4 | 0.8 | 0.2 | 0.3 |
| Late Summer | 387 | Mean | 5.5 | 8.0 | 1.4 | 0.9 | 1.8 | 1.0 | 0.3 | 1.4 | 0.8 | 0.7 | 0.5 |
| | | ± SD | 7.7 | 10.6 | 3.5 | 1.9 | 7.8 | 2.7 | 1.3 | 3.9 | 3.5 | 2.4 | 1.5 |
| Fall | 409 | Mean | 7.9 | 9.5 | 0.9 | 0.8 | 1.6 | 1.4 | 0.4 | 1.8 | 0.5 | 0.6 | 0.9 |
| | | ± SD | 14.9 | 16.0 | 2.0 | 2.3 | 7.8 | 4.8 | 1.1 | 4.4 | 1.9 | 2.5 | 2.6 |
| YEAR | | | | | | | | | | | | | |
| 1975 | 152 | Mean | 5.6 | 4.2 | 1.7 | 0.3 | 0.3 | 0.3 | 0.3 | 1.0 | 0.2 | 0.1 | 0.2 |
| | | ± SD | 9.2 | 4.8 | 5.2 | 1.6 | 1.0 | 1.5 | 0.9 | 3.7 | 1.4 | 0.3 | 0.6 |
| 1976 | 183 | Mean | 13.8 | 6.7 | 3.4 | 0.8 | 0.4 | 1.6 | 0.4 | 1.7 | <0.1 | 0.2 | 0.2 |
| | | ± SD | 22.5 | 8.0 | 11.0 | 1.9 | 1.6 | 5.5 | 1.8 | 4.8 | 0.1 | 0.6 | 0.9 |
| 1977 | 199 | Mean | 14.3 | 12.4 | 2.7 | 0.7 | 0.3 | 1.1 | 0.1 | 1.6 | 0.5 | 0.3 | 0.2 |
| | | ± SD | 23.3 | 15.9 | 6.7 | 1.8 | 0.7 | 3.8 | 0.8 | 4.4 | 1.7 | 1.0 | 0.6 |
| 1978 | 156 | Mean | 15.5 | 10.0 | 2.0 | 1.2 | 3.0 | 1.1 | <0.1 | 1.3 | <0.1 | 0.2 | 0.4 |
| | | ± SD | 33.0 | 16.2 | 4.8 | 4.8 | 8.8 | 2.8 | 0.2 | 3.5 | 0.2 | 0.9 | 1.2 |
| 1980 | 182 | Mean | 8.1 | 10.5 | 2.5 | 0.5 | 0.2 | 1.2 | 0.1 | 0.9 | 0.1 | 0.8 | 0.4 |
| | | ± SD | 11.2 | 13.3 | 6.5 | 1.6 | 0.5 | 3.3 | 0.4 | 2.4 | 0.4 | 3.8 | 1.6 |
| 1981 | 210 | Mean | 14.6 | 15.7 | 1.1 | 1.0 | 4.9 | 1.9 | 0.2 | 0.5 | 0.2 | 0.6 | 0.8 |
| | | ± SD | 22.1 | 22.8 | 2.0 | 2.1 | 14.3 | 4.9 | 0.8 | 1.9 | 1.2 | 2.2 | 2.2 |
| 1982 | 245 | Mean | 9.0 | 13.0 | 1.3 | 1.0 | 1.0 | 1.1 | 0.1 | 0.2 | <0.1 | 0.4 | 0.6 |
| | | ± SD | 13.4 | 34.0 | 2.9 | 2.5 | 3.0 | 2.6 | 0.5 | 1.0 | 0.1 | 1.7 | 2.5 |
| 1983 | 224 | Mean | 13.2 | 7.3 | 3.3 | 0.4 | 0.3 | 0.6 | 0.2 | 0.3 | 1.6 | 0.1 | 0.4 |
| | | ± SD | 39.0 | 14.3 | 10.3 | 1.6 | 1.0 | 1.4 | 0.7 | 1.2 | 4.8 | 0.5 | 1.4 |

[1] Species pairs: sunfish = pumpkinseed and bluegill,
crappie = black and white crappies
bullhead = brown and yellow bullheads

Table 3.2.1-18. Mean No. per lift (± SD) of the principal species and species pairs caught in trap nets at standard Centre Creek locations, 1980-1983 (April - October).[1]

| Summary Variable | No. Lifts | Statistic | Rock Bass | Yellow Perch | FW. Drum | Sm. Bass | White Bass | White Sucker | Sunfish | Crappie | Gizz. Shad | Bull-head | Quill-back |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOCATION | | | | | | | | | | | | | |
| East CCK | 182 | Mean | 20.9 | 15.1 | 0.7 | 1.3 | 4.2 | 0.5 | 0.4 | 0.3 | 0.2 | 0.5 | 0.1 |
| | | ± SD | 54.5 | 35.6 | 1.8 | 4.8 | 16.6 | 1.4 | 1.0 | 0.7 | 0.9 | 1.2 | 0.4 |
| West CCK | 176 | Mean | 17.8 | 15.3 | 0.5 | 0.7 | 2.9 | 1.0 | 0.2 | 0.6 | <0.1 | 0.1 | 0.2 |
| | | ± SD | 39.3 | 26.1 | 1.8 | 4.0 | 9.1 | 5.4 | 0.7 | 1.4 | 0.2 | 0.6 | 0.8 |
| SEASON | | | | | | | | | | | | | |
| Spring | 68 | Mean | 56.8 | 30.8 | 0.8 | 1.6 | 4.3 | 3.1 | 0.4 | 0.3 | <0.1 | 0.4 | 0.1 |
| | | ± SD | 94.1 | 53.9 | 1.7 | 4.4 | 12.5 | 8.6 | 1.1 | 0.7 | 0.2 | 1.2 | 0.5 |
| Early Summer | 105 | Mean | 19.4 | 20.2 | 0.6 | 1.2 | 0.7 | 0.2 | 0.1 | 0.1 | <0.1 | 0.2 | <0.1 |
| | | ± SD | 27.1 | 30.6 | 1.8 | 5.4 | 2.4 | 0.5 | 0.4 | 0.3 | 0.1 | 0.8 | 0.2 |
| Late Summer | 79 | Mean | 6.1 | 11.8 | 0.8 | 0.8 | 1.4 | 0.1 | 0.4 | 0.3 | 0.2 | 0.5 | 0.2 |
| | | ± SD | 7.9 | 15.7 | 2.7 | 2.6 | 6.9 | 0.4 | 0.7 | 0.9 | 0.8 | 1.1 | 0.4 |
| Fall | 106 | Mean | 5.1 | 2.8 | 0.2 | 0.6 | 7.6 | 0.3 | 0.3 | 0.9 | 0.3 | 0.2 | 0.3 |
| | | ± SD | 6.2 | 4.2 | 0.8 | 4.5 | 21.0 | 0.9 | 1.0 | 1.6 | 1.0 | 0.7 | 1.0 |
| YEAR | | | | | | | | | | | | | |
| 1980 | 90 | Mean | 11.0 | 14.0 | 0.3 | <0.1 | 3.3 | 0.3 | <0.1 | 0.4 | <0.1 | <0.1 | 0.2 |
| | | ± SD | 21.6 | 18.2 | 1.0 | 0.1 | 12.3 | 0.9 | 0.2 | 1.1 | 0.2 | 0.1 | 0.9 |
| 1981 | 84 | Mean | 2.9 | 4.0 | 0.2 | <0.1 | 2.7 | 0.1 | <0.1 | 0.1 | 0.0 | <0.1 | <0.1 |
| | | ± SD | 4.7 | 6.1 | 0.5 | 0.1 | 11.0 | 0.4 | 0.2 | 0.5 | 0.0 | 0.2 | 0.1 |
| 1982 | 97 | Mean | 33.3 | 28.1 | 0.4 | 2.4 | 5.6 | 0.7 | 0.5 | 0.5 | 0.1 | 0.9 | 0.2 |
| | | ± SD | 67.6 | 51.9 | 1.0 | 6.4 | 19.7 | 1.7 | 1.1 | 0.9 | 0.7 | 1.5 | 0.7 |
| 1983 | 87 | Mean | 28.4 | 12.8 | 1.4 | 1.3 | 2.4 | 1.9 | 0.6 | 0.6 | 0.3 | 0.3 | 0.2 |
| | | ± SD | 56.2 | 19.0 | 3.2 | 5.6 | 5.8 | 7.6 | 1.1 | 1.5 | 1.1 | 0.8 | 0.5 |

[1] Species pairs: sunfish = pumpkinseed and bluegill
crappie = black and white crappies
bullhead = brown and yellow bullheads

Table 3.2.1-19. One-way analyses of variance testing seasonal mean fork lengths (pooled ages) of yellow perch, rock bass and white bass across the three trapnet crib sizes (6-, 8-, and 10-ft) fished at Centre Creek and Nanticoke, Long Point Bay, Lake Erie (1980-1983).

| | | YEAR | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1980 | | | 1981 | | | 1982 | | | 1983 | | |
| SEASON | SOURCE OF VARIATION | df | SS | F* | df | SS | F* | df | SS | F* | df | SS | F* |
| YELLOW PERCH | | | | | | | | | | | | | |
| Spring | Crib size | 2 | 479082.6 | 151.30[a] | 2 | 255034.3 | 89.17[a] | 2 | 487035.5 | 218.74[a] | 2 | 763703.5 | 187.60[a] |
| | Residual | 1239 | 1964925.3 | | 1412 | 2019181.3 | | 2746 | 3057049.7 | | 1529 | 3115608.4 | |
| | Total | 1241 | 2444007.8 | | 1414 | 2274215.6 | | 2748 | 3544085.2 | | 1531 | 3879311.9 | |
| Summer | Crib size | 2 | 105944.5 | 186.29[a] | 2 | 45705.1 | 61.83[a] | 2 | 122943.3 | 46.79[a] | 2 | 64178.6 | 64.13[a] |
| | Residual | 569 | 161793.5 | | 663 | 245035.9 | | 1404 | 1844623.0 | | 325 | 162631.1 | |
| | Total | 571 | 267737.9 | | 665 | 290741.0 | | 1406 | 1967566.4 | | 327 | 226809.7 | |
| Fall | Crib size | 2 | 33755.2 | 34.60[a] | 2 | 23747.0 | 22.39[a] | 2 | 24679.5 | 15.96[a] | 2 | 66797.8 | 47.04[a] |
| | Residual | 520 | 253656.3 | | 911 | 483175.9 | | 449 | 347136.4 | | 414 | 293964.6 | |
| | Total | 522 | 287411.6 | | 913 | 506923.0 | | 451 | 371815.9 | | 416 | 360762.4 | |
| Combined | Crib size | 2 | 788396.9 | 360.76[a] | 2 | 279254.0 | 142.55[a] | 2 | 664742.6 | 282.90[a] | 2 | 751123.4 | 221.46[a] |
| | Residual | 2334 | 2550335.3 | | 2993 | 2931551.5 | | 4626 | 5435474.4 | | 2274 | 3856436.7 | |
| | Total | 2336 | 3338732.1 | | 2995 | 3210805.4 | | 4628 | 6100216.9 | | 2276 | 4607560.1 | |
| ROCK BASS | | | | | | | | | | | | | |
| Spring | Crib size | 2 | 108302.8 | 39.08[a] | 2 | 68085.0 | 23.78[a] | 2 | 132735.5 | 88.30[a] | 2 | 53334.4 | 44.45[a] |
| | Residual | 1211 | 1678060.8 | | 1486 | 2127619.5 | | 2291 | 1722025.4 | | 2090 | 1253855.9 | |
| | Total | 1213 | 1786363.6 | | 1488 | 2195704.5 | | 2293 | 1854760.8 | | 2092 | 1307190.3 | |
| Summer | Crib size | 2 | 150386.9 | 45.49[a] | 2 | 32903.4 | 14.91[a] | 2 | 84090.9 | 24.74[a] | 2 | 62392.1 | 37.07[a] |
| | Residual | 578 | 955344.9 | | 802 | 884720.2 | | 1208 | 2052781.1 | | 487 | 409886.8 | |
| | Total | 580 | 1105731.8 | | 804 | 9 7623.6 | | 1210 | 2136871.9 | | 489 | 472278.9 | |
| Fall | Crib size | 2 | 9550.4 | 3.09[d] | 2 | 19367.4 | 14.35[a] | 2 | 3278.8 | 2.41 | 2 | 11361.4 | 8.20[b] |
| | Residual | 421 | 650634.5 | | 930 | 627625.9 | | 572 | 389427.3 | | 551 | 381927.3 | |
| | Total | 423 | 660184.9 | | 932 | 646993.3 | | 574 | 392706.1 | | 553 | 393288.6 | |
| Combined | Crib size | 2 | 118426.7 | 31.40[a] | 2 | 120172.7 | 48.34[a] | 2 | 217711.1 | 101.44[a] | 2 | 117111.6 | 88.30[a] |
| | Residual | 2216 | 4179510.9 | | 3224 | 4007353.1 | | 4084 | 4382623.3 | | 3134 | 2078405.6 | |
| | Total | 2218 | 4297937.6 | | 3226 | 4127525.8 | | 4086 | 4600334.3 | | 3136 | 2195517.3 | |
| WHITE BASS | | | | | | | | | | | | | |
| Spring | Crib size | 1 | 6666.7 | 5.33 | 2 | 22124.4 | 44.88[a] | 2 | 77525.1 | 24.90[a] | 2 | 5816.4 | 1.56 |
| | Residual | 1 | 1250.0 | | 353 | 87013.1 | | 226 | 351848.0 | | 53 | 98852.4 | |
| | Total | 2 | 7916.7 | | 355 | 109137.5 | | 228 | 429373.1 | | 55 | 104668.8 | |
| Summer | Crib size | | | | 2 | 2792.8 | 7.80[b] | 2 | 2113.1 | 6.00[c] | 2 | 10670.0 | 34.94[a] |
| | Residual | | | | 443 | 79324.3 | | 226 | 39819.5 | | 10 | 1526.8 | |
| | Total | | | | 445 | 82117.1 | | 228 | 41932.7 | | 12 | 12196.8 | |
| Fall | Crib size | 2 | 216705.6 | 51.62[a] | 2 | 2312.9 | 4.96[c] | 2 | 86590.9 | 63.04[a] | 1 | 4.1 | 0.01 |
| | Residual | 325 | 682200.8 | | 270 | 62997.9 | | 245 | 168251.1 | | 193 | 141041.4 | |
| | Total | 327 | 898906.4 | | 272 | 65310.8 | | 247 | 254842.0 | | 194 | 141045.5 | |
| Combined | Crib size | 2 | 239661.2 | 57.42[a] | 2 | 342395.6 | 392.31[a] | 2 | 115315.7 | 64.90[a] | 2 | 6540.1 | 3.24[d] |
| | Residual | 329 | 686608.0 | | 1072 | 467806.7 | | 720 | 619654.7 | | 261 | 263627.2 | |
| | Total | 331 | 926269.2 | | 1074 | 810202.3 | | 722 | 754970.4 | | 263 | 270167.3 | |

* a = significant at $p = 0.0001$
b = significant at $p < 0.001$
c = significant at $p < 0.01$
d = significant at $p < 0.05$

Table 3.2.1-20. Analyses of variance testing spring fork lengths-at-age of (A) yellow perch and (B) rock bass across the three trapnet crib sizes fished at Centre Creek and Nanticoke, Long Point Bay, Lake Erie (1980-1983).

A. YELLOW PERCH

| SOURCE OF VARIATION | AGE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | II | | | III | | | IV | | | V | | |
| | df | SS | F* | df | SS | F* | df | SS | F* | df | SS | F* |
| Main Effects: Year | 3 | 2907.2 | 7.84$^a$ | 3 | 1822.0 | 3.11$^d$ | 3 | 2883.1 | 1.56 | 3 | 10316.6 | 2.41 |
| Crib Size | 2 | 15573.1 | 63.02$^a$ | 2 | 132248.5 | 338.54$^a$ | 2 | 26430.5 | 21.47$^a$ | 2 | 3130.3 | 1.10 |
| Year x Crib Size | 3 | 2472.2 | 6.67$^b$ | 6 | 7517.8 | 6.41$^a$ | 6 | 7523.5 | 2.04 | 6 | 6215.7 | 0.73 |
| Explained | 8 | 39176.2 | 39.63$^a$ | 11 | 181055.3 | 84.27$^a$ | 11 | 49185.0 | 7.27$^a$ | 11 | 71307.2 | 4.55$^a$ |
| Residual | 475 | 58689.9 | | 3450 | 673862.6 | | 1356 | 834558.2 | | 282 | 401620.2 | |
| Total | 483 | 97866.1 | | 3461 | 854918.0 | | 1367 | 883743.2 | | 293 | 472927.3 | |

B. ROCK BASS

| SOURCE OF VARIATION | AGE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | III | | | IV | | | V | | | VI | | |
| | df | SS | F* | df | SS | F* | df | SS | F* | df | SS | F* |
| Main Effects: Year | 3 | 2382.2 | 1.85 | 3 | 6178.1 | 7.66$^a$ | 3 | 3160.5 | 4.73$^c$ | 3 | 17107.4 | 28.32$^a$ |
| Crib Size | 2 | 855.7 | 1.00 | 2 | 25261.8 | 46.97$^a$ | 2 | 1133.4 | 2.55 | 2 | 2955.7 | 7.34$^b$ |
| Year x Crib Size | 3 | 719.7 | 0.56 | 6 | 1583.8 | 0.98 | 6 | 1688.5 | 1.26 | 6 | 1512.6 | 1.25 |
| Explained | 8 | 8640.3 | 2.52$^d$ | 11 | 42175.8 | 14.26$^a$ | 11 | 23608.4 | 9.64$^a$ | 11 | 38637.4 | 17.44$^a$ |
| Residual | 183 | 78531.7 | | 1268 | 341017.8 | | 2150 | 478736.3 | | 1553 | 312720.4 | |
| Total | 191 | 87171.9 | | 1279 | 383193.6 | | 2161 | 502344.7 | | 1564 | 351357.8 | |

*a = Significant at $p = 0.0001$
b = Significant at $p < 0.001$
c = Significant at $p < 0.01$
d = Significant at $p < 0.05$

Table 3.2.1-21. Analyses of variance testing (A) seasonal mean fork lengths (pooled ages) and (B) backcalculated fork lengths-at-age of yellow perch and rock bass across the five standard Nanticoke trap nets; Long Point Bay, Lake Erie (1981-1983).

A. FORK LENGTH (Pooled Ages)

| SOURCE OF VARIATION | YELLOW PERCH | | | ROCK BASS | | |
|---|---|---|---|---|---|---|
| | df | SS | F* | df | SS | F* |
| | | | SPRING | | | |
| Main Effects: Year | 2 | 40000.3 | 12.54$^a$ | 2 | 2515.3 | 1.67 |
| Location | 4 | 297411.2 | 46.62$^a$ | 4 | 55630.8 | 18.45$^a$ |
| Year x Location | 8 | 18912.9 | 1.48 | 8 | 32659.3 | 5.42$^a$ |
| Explained | 14 | 479229.3 | 21.46$^a$ | 14 | 116029.2 | 10.99$^a$ |
| Residual | 2249 | 3587175.7 | | 2245 | 1692299.1 | |
| Total | 2263 | 4066405.0 | | 2259 | 1808328.3 | |
| | | | SUMMER | | | |
| Main Effects: Year | 2 | 3101.2 | 2.88 | 2 | 107355.1 | 71.15$^a$ |
| Location | 4 | 77458.0 | 35.95$^a$ | 4 | 63652.5 | 21.09$^a$ |
| Year x Location | 8 | 16065.2 | 3.73$^b$ | 8 | 30856.8 | 5.11$^a$ |
| Explained | 14 | 89856.3 | 11.92$^a$ | 14 | 436513.4 | 41.33$^a$ |
| Residual | 1871 | 1007791.9 | | 1998 | 1507328.9 | |
| Total | 1885 | 1097648.2 | | 2012 | 1943842.3 | |
| | | | FALL | | | |
| Main Effects: Year | 2 | 114.4 | 0.11 | 2 | 22909.1 | 18.29$^a$ |
| Location | 4 | 14907.6 | 7.29$^a$ | 4 | 19453.0 | 7.77$^a$ |
| Year x Location | 8 | 20677.3 | 5.05$^a$ | 8 | 8403.5 | 1.68 |
| Explained | 14 | 38427.1 | 5.37$^a$ | 14 | 100665.7 | 11.48$^a$ |
| Residual | 1260 | 644271.2 | | 1073 | 671816.6 | |
| Total | 1274 | 682698.3 | | 1087 | 772482.2 | |

* a = significant at $p = 0.0001$   b = significant at $p < 0.001$

B. BACKCALCULATED LENGTH-AT-AGE

| SOURCE OF VARIATION | YELLOW PERCH | | | ROCK BASS | | |
|---|---|---|---|---|---|---|
| | df | SS | F* | df | SS | F* |
| | | | AGE = 3 | | | |
| Main Effects: Year | 2 | 2183.7 | 4.87$^b$ | 2 | 569.4 | 1.22$^c$ |
| Location | 4 | 5700.0 | 6.36$^a$ | 4 | 1102.4 | 1.18 |
| Year x Location | 8 | 7825.0 | 4.37$^a$ | 8 | 2081.3 | 1.12 |
| Explained | 14 | 23707.4 | 7.56$^a$ | 14 | 7663.2 | 2.35 |
| Residual | 2649 | 593507.8 | | 390 | 90941.7 | |
| Total | 2663 | 617215.3 | | 404 | 98604.8 | |
| | | | AGE = 4 | | | |
| Main Effects: Year | 2 | 480.5 | 0.41 | 2 | 14768.3 | 27.10$^a$ |
| Location | 4 | 17578.5 | 7.43$^a$ | 4 | 20865.6 | 19.14$^a$ |
| Year x Location | 8 | 27106.2 | 5.73$^a$ | 8 | 7629.2 | 3.50$^b$ |
| Explained | 14 | 54304.8 | | 14 | 70552.6 | 18.49$^a$ |
| Residual | 1296 | 766630.2 | | 1785 | 486374.3 | |
| Total | 1310 | 820935.0 | | 1799 | 556926.9 | |
| | | | AGE = 5 | | | |
| Main Effects: Year | 2 | 14808.9 | 4.98$^c$ | 2 | 164.4 | 0.38 |
| Location | 4 | 57330.0 | 9.64$^a$ | 4 | 9780.3 | 11.29$^a$ |
| Year x Location | 8 | 8762.5 | 0.74 | 8 | 2609.6 | 1.51 |
| Explained | 14 | 83922.9 | 4.03 | 14 | 13777.7 | 4.54$^a$ |
| Residual | 189 | 281105.7 | | 1330 | 287994.9 | |
| Total | 203 | 365028.6 | | 1334 | 301772.6 | |

* a = significant at $p = 0.0001$
b = significant at $p < 0.001$
c = significant at $p < 0.01$

Table 3.2.1-22. One-way analyses of variance testing mean fork lengths of selected fish species between the East and West Plume trap nets, Long Point Bay, Lake Erie (1982-1983).

| SOURCE OF VARIATION | 1982 | | | | | 1983 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | df | SS | MS | F | P | df | SS | MS | F | P |
| **YELLOW PERCH** | | | | | | | | | | |
| Main Effect: Location | 1 | 66270.1 | 66270.1 | 38.06 | 0.0001 | 1 | 6644.7 | 6644.7 | 5.05 | 0.0249 |
| Residual | 1599 | 2784147.1 | 1741.2 | | | 940 | 1237798.1 | 1316.8 | | |
| Total | 1600 | 2850417.2 | | | | 941 | 1244442.8 | | | |
| **SMALLMOUTH BASS** | | | | | | | | | | |
| Main Effect: Location | 1 | 117850.7 | 117850.7 | 40.45 | 0.0001 | 1 | 73.5 | 73.5 | 0.03 | 0.8533 |
| Residual | 143 | 416632.6 | 2913.5 | | | 46 | 97825.8 | 2126.6 | | |
| Total | 144 | 534483.2 | | | | 47 | 97899.3 | | | |
| **WHITE BASS** | | | | | | | | | | |
| Main Effect: Location | 1 | 22553.0 | 22553.0 | 25.18 | 0.0001 | 1 | 255.6 | 255.6 | 0.52 | 0.4763 |
| Residual | 120 | 107495.6 | 895.8 | | | 46 | 22793.9 | 495.5 | | |
| Total | 121 | 130048.5 | | | | 47 | 23049.5 | | | |
| **ROCK BASS** | | | | | | | | | | |
| Main Effect: Location | 1 | 4738.1 | 4738.1 | 3.88 | 0.0490 | 1 | 5988.8 | 5988.8 | 8.97 | 0.0028 |
| Residual | 1441 | 1759388.2 | 1220.9 | | | 1118 | 746320.5 | 667.5 | | |
| Total | 1442 | 1764126.3 | | | | 1119 | 752309.2 | | | |

Table 3.2.1-23. One-way analyses of variance testing spring fork length-at-age of yellow perch and rock bass between East and West Plume trap nets, Long Point Bay, Lake Erie (1982-1983).

| SOURCE OF VARIATION | YELLOW PERCH | | | | | | | | | | ROCK BASS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1982 | | | | | 1983 | | | | | 1982 | | | | | 1983 | | | | |
| | df | SS | MS | F | P | df | SS | MS | F | P | df | SS | MS | F | P | df | SS | MS | F | P |
| AGE = 3 | | | | | | | | | | | | | | | | | | | | |
| Main Effect: Location | 1 | 4379.7 | 4379.7 | 36.43 | 0.0001 | 1 | 1253.1 | 1253.1 | 8.93 | 0.0031 | | | | | | | | | | |
| Residual | 717 | 86187.6 | 120.2 | | | 218 | 30593.0 | 140.3 | | | | | | | | | | | | |
| Total | 718 | 90567.3 | | | | 219 | 31846.1 | | | | | | | | | | | | | |
| AGE = 4 | | | | | | | | | | | | | | | | | | | | |
| Main Effect: Location | 1 | 3615.2 | 3615.2 | 5.81 | 0.0172 | 1 | 4394.5 | 4394.5 | 6.97 | 0.0090 | 1 | 1094.3 | 1094.3 | 3.67 | 0.0577 | 1 | 312.2 | 312.2 | 0.66 | 0.4199 |
| Residual | 136 | 84567.8 | 621.8 | | | 192 | 121014.0 | 630.3 | | | 129 | 38476.3 | 298.3 | | | 41 | 19281.5 | 470.3 | | |
| Total | 137 | 88182.9 | | | | 193 | 125408.5 | | | | 130 | 39570.6 | | | | 42 | 19593.6 | | | |
| AGE = 5 | | | | | | | | | | | | | | | | | | | | |
| Main Effect: Location | 1 | 5760.3 | 5760.3 | 3.49 | 0.0688 | | | | | | 1 | 131.1 | 131.1 | 0.68 | 0.4082 | 1 | 395.3 | 395.3 | 2.18 | 0.1414 |
| Residual | 41 | 67615.5 | 1649.2 | | | | | | | | 537 | 102761.8 | 191.4 | | | 197 | 35715.8 | 181.3 | | |
| Total | 42 | 73375.9 | | | | | | | | | 538 | 102892.9 | | | | 198 | 36111.2 | | | |
| AGE = 6 | | | | | | | | | | | | | | | | | | | | |
| Main Effect: Location | | | | | | | | | | | 1 | 8.7 | 8.7 | 0.04 | 0.8489 | 1 | 138.4 | 138.4 | 0.77 | 0.3824 |
| Residual | | | | | | | | | | | 80 | 19066.9 | 238.3 | | | 294 | 53183.7 | 180.9 | | |
| Total | | | | | | | | | | | 81 | 19075.6 | | | | 295 | 53322.2 | | | |

Table 3.2.1-24. Age composition (%) of (A) yellow perch and (B) rock bass catches in selected trapnet groups fished at Centre Creek and Nanticoke, Long Point Bay, Lake Erie (1980-1983).

A. YELLOW PERCH

| TRAPNET GROUP | | 1980 | | | 1981 | | | 1982 | | | 1983 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year Class | 1978 | 1977 | 1976- | 1979 | 1978 | 1977- | 1980 | 1979 | 1978- | 1981 | 1980 | 1979- |
| | Age | II | III | IV+ | II | III | IV+ | II | III | IV+ | II | III | IV+ |
| 8- and 10-ft nets pooled (Nanticoke) | | 15.1 | 64.8 | 20.0 | 23.8 | 44.0 | 31.9 | 5.6 | 71.8 | 22.5 | 23.1 | 35.7 | 41.2 |
| 6-ft nets pooled (Center Creek) | | 18.9 | 76.0 | 4.9 | 39.5 | 42.7 | 17.5 | 17.4 | 67.9 | 14.5 | 50.2 | 24.6 | 24.8 |
| 8-ft nets pooled (Nanticoke) | | 15.4 | 64.2 | 20.3 | 24.0 | 43.7 | 32.2 | 5.9 | 72.2 | 22.0 | 23.5 | 36.0 | 40.6 |
| West Plume 8-ft net | | 23.4 | 70.3 | 6.1 | 27.5 | 45.2 | 27.2 | 5.3 | 76.8 | 17.9 | 28.0 | 35.7 | 36.3 |
| Oneida 10-ft net | | 15.1 | 69.1 | 15.9 | 24.8 | 45.9 | 29.1 | 4.0 | 63.3 | 32.5 | 11.1 | 30.6 | 58.4 |

B. ROCK BASS

| TRAPNET GROUP | | 1980 | | | 1981 | | | 1982 | | | 1983 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year Class | 1977 | 1976 | 1975- | 1978 | 1977 | 1976- | 1979 | 1978 | 1977- | 1980 | 1979 | 1978- |
| | Age | II | III | IV+ | II | III | IV+ | II | III | IV+ | II | III | IV+ |
| 8- and 10-ft nets pooled (Nanticoke) | | 23.3 | 12.3 | 63.5 | 11.7 | 55.0 | 32.9 | 3.2 | 23.3 | 72.9 | 2.5 | 9.4 | 88.0 |
| 6-ft nets pooled (Center Creek) | | 31.3 | 14.6 | 53.0 | 13.7 | 70.5 | 14.8 | 6.6 | 35.6 | 57.5 | 2.4 | 16.9 | 80.2 |
| 8-ft nets pooled (Nanticoke) | | 24.1 | 12.4 | 62.6 | 12.1 | 55.1 | 32.4 | 3.4 | 24.6 | 71.3 | 2.6 | 10.0 | 87.3 |
| West Plume 8-ft net | | 18.7 | 10.1 | 70.8 | 17.5 | 62.3 | 18.6 | 2.9 | 23.5 | 72.4 | 3.8 | 11.0 | 85.0 |
| Oneida 10-ft net | | 12.5 | 11.5 | 75.0 | 3.9 | 52.9 | 43.2 | 2.3 | 6.0 | 91.5 | 2.3 | 6.0 | 91.5 |

Table 3.2.1-25. Seasonal age composition (%) of smallmouth bass and white bass in Nanticoke (8- and 10-ft nets pooled) and Centre Creek (6-ft nets pooled) trapnet catches, Long Point Bay, Lake Erie (1980-1983).

| | | | SMALLMOUTH BASS | | | | | | | | WHITE BASS | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | NANTICOKE | | | | CENTER CREEK | | | | NANTICOKE | | | | CENTER CREEK | | | |
| YEAR | YEAR CLASS | AGE | Spring | Summer | Fall | Seasons Combined | Spring | Summer | Fall | Seasons Combined | Spring | Summer | Fall | Seasons Combined | Spring | Summer | Fall | Seasons Combined |
| 1980 | 1980 | 0 | | | | | | | | | | | 27.3 | 24.0 | | | 99.7 | 99.3 |
| | 1979 | I | | | 3.9 | 2.4 | | | | | | 50.0 | 59.1 | 56.0 | 100.0 | | 0.3 | 0.7 |
| | 1978 | II | | 14.3 | 17.3 | 15.7 | | | | | 100.0 | 50.0 | 9.1 | 12.0 | | | | |
| | 1977 | III | | 64.3 | 55.8 | 56.6 | | | | | | | 4.6 | 8.0 | | | | |
| | 1976 | IV | 33.3 | 3.6 | 9.6 | 8.4 | | | | | | | | | | | | |
| | 1975 | V | 33.3 | 7.1 | 3.8 | 6.0 | | | | | | | | | | | | |
| | 1974 | VI | 33.3 | 3.6 | 3.8 | 4.8 | | | | | | | | | | | | |
| | 1973 | VII | | 3.6 | 3.8 | 3.6 | | | | | | | | | | | | |
| | 1972 | VIII | | 3.6 | 1.9 | 2.4 | | | | | | | | | | | | |
| | N | | 3 | 28 | 52 | 83 | | | | | 1 | 2 | 22 | 25 | 1 | 0 | 306 | 307 |
| 1981 | 1981 | 0 | | | | | | | | | | | 0.5 | 0.1 | | 23.1 | 20.0 | 2.2 |
| | 1980 | I | | 1.5 | 34.3 | 8.1 | | | | | 97.0 | 98.2 | 99.5 | 98.4 | 100.0 | 76.9 | 80.0 | 97.8 |
| | 1979 | II | | 13.8 | 5.7 | 11.6 | | | | | 2.3 | 1.6 | | 1.3 | | | | |
| | 1978 | III | | 60.0 | 37.1 | 52.6 | | | | | 0.8 | 0.2 | | 0.3 | | | | |
| | 1977 | IV | 62.5 | 21.5 | 14.3 | 22.0 | | | | | | | | | | | | |
| | 1976 | V | 37.5 | 0.8 | 5.7 | 3.5 | | | | | | | | | | | | |
| | 1975 | VI | | 0.8 | —— | 0.6 | | | | | | | | | | | | |
| | 1974 | VII | | 0.8 | —— | 0.6 | | | | | | | | | | | | |
| | 1973 | VIII | | 0.8 | 2.9 | 1.2 | | | | | | | | | | | | |
| | N | | 8 | 130 | 35 | 173 | | | | | 132 | 449 | 207 | 788 | 167 | 13 | 5 | 185 |
| 1982 | 1982 | 0 | | | | | | | | | | | 1.3 | 6.0 | | | 42.6 | 11.3 |
| | 1981 | I | | 4.6 | 7.1 | 4.8 | | 1.4 | | 0.5 | 40.9 | 83.3 | 96.2 | 73.1 | 88.1 | 91.3 | 57.4 | 81.6 |
| | 1980 | II | | 65.5 | 59.2 | 50.7 | 1.2 | 54.1 | 64.2 | 35.4 | 59.2 | 16.7 | 2.6 | 20.9 | 11.9 | 8.2 | | 6.9 |
| | 1979 | III | 2.4 | 5.8 | 7.1 | 5.7 | 10.6 | 24.3 | 17.0 | 17.0 | | | | | | 0.5 | | 0.2 |
| | 1978 | IV | 40.5 | 20.7 | 17.3 | 22.9 | 51.8 | 14.9 | 18.9 | 30.7 | | | | | | | | |
| | 1977 | V | 26.2 | 1.2 | 7.1 | 8.4 | 32.9 | 5.4 | | 15.1 | | | | | | | | |
| | 1976 | VI | 16.7 | 2.3 | —— | 4.0 | 1.2 | | | 0.5 | | | | | | | | |
| | 1975 | VII | 7.1 | | 1.0 | 1.8 | 2.4 | | | 1.0 | | | | | | | | |
| | 1974 | VIII | —— | | 1.0 | 0.4 | | | | | | | | | | | | |
| | 1973 | IX | 4.8 | | | 0.9 | | | | | | | | | | | | |
| | 1972 | X | —— | | | —— | | | | | | | | | | | | |
| | 1971 | XI | 2.4 | | | 0.4 | | | | | | | | | | | | |
| | N | | 42 | 87 | 98 | 227 | 85 | 74 | 53 | 212 | 71 | 72 | 78 | 268 | 101 | 219 | 115 | 435 |
| 1983 | 1983 | 0 | | | | | | | | | | | | | | | 2.0 | 1.5 |
| | 1982 | I | | | 14.3 | 2.3 | | 2.4 | | 1.9 | | 22.2 | 81.1 | 54.2 | 56.0 | 19.1 | 76.0 | 67.4 |
| | 1981 | II | | 40.0 | 50.0 | 12.4 | | 23.5 | 100.0 | 20.2 | 100.0 | 66.7 | 18.9 | 44.1 | 40.0 | 81.0 | 22.0 | 30.6 |
| | 1980 | III | 32.3 | 60.0 | 35.7 | 36.0 | 38.9 | 71.8 | | 65.4 | | 11.1 | | 1.7 | 4.0 | | | 0.5 |
| | 1979 | IV | 36.9 | | | 27.0 | 11.1 | 2.4 | | 3.8 | | | | | | | | |
| | 1978 | V | 21.5 | | | 15.7 | 44.4 | | | 7.7 | | | | | | | | |
| | 1977 | VI | 9.2 | | | 6.7 | 5.6 | | | 1.0 | | | | | | | | |
| | N | | 65 | 10 | 14 | 89 | 18 | 85 | 2 | 104 | 13 | 9 | 37 | 59 | 25 | 17 | 150 | 196 |

. Table 3.2.1-26 Age composition (%) of yellow perch in Nanticoke (8- and 10-ft nets pooled) trapnet catches, Long Point Bay, Lake Erie (1980-1983).

| | 1980 | | | | | | | | | | N | 1981 | | | | | | | | | | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR CLASS | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | 1970 | 1969 | | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | 1970 | |
| AGE | II | III | IV | V | VI | VII | VIII | IX | X | XI | | II | III | IV | V | VI | VII | VIII | IX | X | XI | |
| Spring | | | | | | | | | | | | | | | | | | | | | | |
| Males | 0.0 | 22.2 | 6.0 | 1.9 | 0.2 | 0.8 | 0.2 | 0.0 | 0.0 | | 166 | 1.3 | 24.2 | 14.5 | 1.7 | 0.3 | 0.3 | 0.3 | 0.3 | 0.0 | | 134 |
| Females | 0.4 | 45.0 | 6.4 | 4.7 | 3.6 | 4.3 | 2.5 | 1.7 | 0.2 | | 365 | 1.3 | 36.4 | 11.1 | 3.4 | 2.7 | 0.0 | 1.7 | 0.0 | 0.3 | | 176 |
| Combined | 0.4 | 67.2 | 12.4 | 6.6 | 3.8 | 5.1 | 2.6 | 1.7 | 0.2 | | 531 | 1.4 | 50.9 | 34.7 | 4.1 | 4.0 | 2.4 | 1.9 | 0.4 | 0.1 | | 752 |
| Early Summer | | | | | | | | | | | | | | | | | | | | | | |
| Males | 1.3 | 19.9 | 8.7 | 0.9 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | | 72 | 1.3 | 23.4 | 23.4 | 1.6 | 0.3 | 0.0 | 0.0 | 0.0 | | | 160 |
| Females | 0.0 | 48.9 | 6.5 | 3.0 | 2.2 | 2.2 | 3.0 | 2.2 | 0.9 | | 159 | 1.6 | 33.0 | 12.5 | 0.3 | 1.0 | 0.6 | 0.6 | 0.3 | | | 156 |
| Combined | 1.3 | 68.8 | 15.2 | 3.9 | 2.2 | 2.2 | 3.5 | 2.2 | 0.9 | | 231 | 2.5 | 51.0 | 40.3 | 2.7 | 1.3 | 0.9 | 1.1 | 0.2 | | | 449 |
| Late Summer | | | | | | | | | | | | | | | | | | | | | | |
| Males | 1.9 | 24.7 | 6.3 | --- | --- | 0.0 | | | | | 52 | 7.5 | 26.6 | 15.0 | | | | | | | | 225 |
| Females | 3.8 | 60.8 | 1.9 | --- | --- | 0.6 | | | | | 106 | 17.7 | 24.8 | 6.8 | 0.9 | | | | | | | 223 |
| Combined | 6.3 | 85.0 | 8.1 | --- | --- | 0.6 | | | | | 160 | 23.5 | 51.9 | 22.8 | 1.8 | | | | | | | 501 |
| Fall | | | | | | | | | | | | | | | | | | | | | | |
| Males | 9.1 | 18.8 | 0.9 | 0.0 | 0.0 | 0.0 | | | | | 128 | 12.6 | 9.6 | 5.6 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | | | 141 |
| Females | 34.2 | 33.6 | 1.4 | 0.5 | 0.7 | 0.5 | | | | | 313 | 52.0 | 15.0 | 2.8 | 0.2 | 0.8 | 0.0 | 0.4 | 0.2 | | | 359 |
| Combined | 43.3 | 52.4 | 2.3 | 0.5 | 0.7 | 0.5 | | | | | 441 | 61.7 | 26.6 | 9.3 | 0.9 | 0.7 | 0.1 | 0.3 | 0.1 | | | 699 |
| Seasons Combined | | | | | | | | | | | | | | | | | | | | | | |
| Males | 3.4 | 21.0 | 4.9 | 0.9 | 0.1 | 0.3 | 0.2 | 0.0 | 0.0 | | 418 | 6.7 | 20.0 | 13.5 | 0.9 | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 | | 644 |
| Females | 11.7 | 43.8 | 4.3 | 2.5 | 2.0 | 2.3 | 1.5 | 1.0 | 0.2 | | 943 | 22.5 | 25.5 | 7.5 | 1.0 | 1.0 | 0.1 | 0.6 | 0.1 | 0.1 | | 906 |
| Combined | 15.1 | 64.8 | 9.1 | 3.4 | 2.1 | 2.6 | 1.6 | 1.0 | 0.2 | | 1363 | 23.8 | 44.0 | 25.6 | 2.4 | 1.7 | 1.0 | 0.9 | 0.2 | 0.1 | | 2402 |

| | 1982 | | | | | | | | | | N | 1983 | | | | | | | | | | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR CLASS | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | | 1981 | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | |
| AGE | II | III | IV | V | VI | VII | VIII | IX | X | XI | | II | III | IV | V | VI | VII | VIII | IX | X | XI | |
| Spring | | | | | | | | | | | | | | | | | | | | | | |
| Males | 0.6 | 21.6 | 8.7 | 2.8 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 183 | 0.8 | 8.7 | 14.3 | 0.3 | 0.3 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 88 |
| Females | 0.0 | 41.5 | 9.8 | 4.4 | 2.2 | 3.3 | 1.8 | 1.8 | 0.9 | 0.4 | 359 | 2.0 | 28.1 | 20.5 | 6.7 | 8.4 | 2.8 | 3.7 | 2.2 | 0.3 | 0.6 | 268 |
| Combined | 0.5 | 67.6 | 18.2 | 6.8 | 1.8 | 2.1 | 1.1 | 1.0 | 0.7 | 0.2 | 1009 | 2.2 | 39.9 | 34.8 | 6.9 | 7.5 | 2.8 | 3.2 | 2.1 | 0.2 | 0.4 | 534 |
| Early Summer | | | | | | | | | | | | | | | | | | | | | | |
| Males | 0.8 | 27.3 | 10.7 | 2.3 | 0.0 | 0.5 | 0.0 | | | | 160 | 0.0 | 13.0 | 37.0 | 3.4 | 0.0 | 0.0 | 0.0 | 0.0 | | | 78 |
| Females | 3.9 | 49.5 | 2.3 | 1.3 | 0.3 | 0.5 | 0.5 | | | | 224 | 3.4 | 26.7 | 13.7 | 0.0 | 0.7 | 0.7 | 0.7 | 0.7 | | | 88 |
| Combined | 4.1 | 78.0 | 13.6 | 2.9 | 0.4 | 0.7 | 0.4 | | | | 559 | 4.7 | 44.2 | 42.9 | 3.0 | 1.3 | 0.9 | 2.1 | 0.9 | | | 233 |
| Late Summer | | | | | | | | | | | | | | | | | | | | | | |
| Males | 0.3 | 32.6 | 13.0 | 0.6 | --- | --- | --- | 0.0 | | | 150 | 5.7 | 26.0 | 29.3 | 1.6 | --- | | | | | | 72 |
| Females | 4.7 | 46.3 | 1.2 | 0.9 | --- | --- | --- | 0.3 | | | 172 | 16.3 | 17.1 | 4.1 | 0.0 | --- | | | | | | 46 |
| Combined | 5.3 | 79.9 | 13.4 | 1.2 | --- | --- | --- | 0.2 | | | 433 | 24.6 | 42.1 | 30.6 | 2.2 | --- | 0.5 | | | | | 183 |
| Fall | | | | | | | | | | | | | | | | | | | | | | |
| Males | 4.5 | 32.1 | 5.1 | 0.6 | 0.0 | --- | 0.0 | | | | 66 | 11.7 | 7.9 | 3.4 | 0.4 | 0.0 | 0.0 | 0.0 | | | | 62 |
| Females | 17.9 | 34.6 | 2.6 | 0.6 | 1.3 | --- | 0.6 | | | | 90 | 59.6 | 10.6 | 3.0 | 1.9 | 0.8 | 0.4 | 0.4 | | | | 203 |
| Combined | 22.8 | 66.4 | 8.3 | 0.8 | 0.8 | --- | 0.4 | 0.4 | | | 241 | 71.0 | 18.6 | 6.9 | 2.2 | 0.6 | 0.3 | 0.3 | | | | 317 |
| Seasons Combined | | | | | | | | | | | | | | | | | | | | | | |
| Males | 1.1 | 26.2 | 9.4 | 1.8 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 576 | 4.6 | 11.6 | 16.9 | 1.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 305 |
| Females | 5.4 | 43.8 | 4.9 | 2.4 | 1.1 | 1.5 | 0.9 | 0.7 | 0.4 | 0.1 | 908 | 21.3 | 21.1 | 11.9 | 3.3 | 3.7 | 1.3 | 1.7 | 1.0 | 0.1 | 0.2 | 585 |
| Combined | 5.6 | 71.8 | 14.8 | 4.0 | 1.0 | 1.2 | 0.6 | 0.5 | 0.3 | 0.1 | 2322 | 23.1 | 35.7 | 28.7 | 4.3 | 3.6 | 1.5 | 1.8 | 1.0 | 0.1 | 0.2 | 1267 |

Table 3.2.1-27. Age composition (%) of yellow perch in Centre Creek (6-ft nets pooled) trapnet catches, Long Point Bay, Lake Erie (1980-1983).

**1980**

| YEAR CLASS | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | 1970 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGE | I | II | III | IV | V | VI | VII | VIII | IX | X | N |
| **Spring** | | | | | | | | | | | |
| Males | | 1.2 | 25.8 | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | 72 |
| Females | | 4.1 | 61.5 | 0.4 | 1.2 | 1.2 | 0.8 | 0.4 | 0.8 | | 172 |
| Combined | | 5.3 | 87.3 | 2.9 | 1.2 | 1.2 | 0.8 | 0.4 | 0.8 | | 244 |
| **Early Summer** | | | | | | | | | | | |
| Males | | 3.2 | 37.7 | 2.6 | | | | | | | 135 |
| Females | | 6.8 | 47.1 | 2.6 | | | | | | | 175 |
| Combined | | 10.0 | 84.9 | 5.1 | | | | | | | 311 |
| **Late Summer** | | | | | | | | | | | |
| Males | 0.0 | 16.0 | 38.7 | 1.2 | 0.4 | | | | | | 137 |
| Females | 0.4 | 18.9 | 23.5 | 0.8 | 0.0 | | | | | | 106 |
| Combined | 0.4 | 34.8 | 62.5 | 2.0 | 0.4 | | | | | | 253 |
| **Fall** | | | | | | | | | | | |
| Males | | 26.3 | 15.8 | 2.6 | | | | | | | 17 |
| Females | | 47.4 | 5.3 | 2.6 | | | | | | | 21 |
| Combined | | 73.7 | 21.1 | 5.3 | | | | | | | 38 |
| **Seasons Combined** | | | | | | | | | | | |
| Males | 0.0 | 7.4 | 33.5 | 2.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | | 361 |
| Females | 0.1 | 11.4 | 42.5 | 1.4 | 0.4 | 0.4 | 0.2 | 0.1 | 0.2 | | 474 |
| Combined | 0.1 | 18.9 | 76.0 | 3.5 | 0.5 | 0.4 | 0.2 | 0.1 | 0.2 | | 846 |

**1981**

| YEAR CLASS | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGE | I | II | III | IV | V | VI | VII | VIII | IX | X | N |
| **Spring** | | | | | | | | | | | |
| Males | | 9.9 | 24.2 | 6.6 | 1.1 | | | | | | 38 |
| Females | | 37.4 | 19.8 | 0.0 | 1.1 | | | | | | 53 |
| Combined | | 25.1 | 55.4 | 18.3 | 1.1 | | | | | | 175 |
| **Early Summer** | | | | | | | | | | | |
| Males | | 15.2 | 21.2 | 7.6 | | | | | | | 29 |
| Females | | 36.4 | 12.1 | 6.1 | | | | | | | 36 |
| Combined | | 42.5 | 38.8 | 17.5 | 1.3 | | | | | | 80 |
| **Late Summer** | | | | | | | | | | | |
| Males | | 45.0 | 0.0 | | 5.0 | --- | | | | | 10 |
| Females | | 45.0 | 5.0 | | 0.0 | --- | | | | | 10 |
| Combined | | 81.5 | 7.4 | 3.7 | 3.7 | --- | 3.7 | | | | 27 |
| **Fall** | | | | | | | | | | | |
| Males | 0.0 | 34.8 | 0.0 | 0.0 | | | | | | | 8 |
| Females | 4.3 | 52.2 | 4.3 | 4.3 | | | | | | | 15 |
| Combined | 3.7 | 81.5 | 7.4 | 7.4 | | | | | | | 27 |
| **Seasons Combined** | | | | | | | | | | | |
| Males | 0.0 | 18.0 | 18.0 | 5.5 | 1.0 | --- | | | | | 85 |
| Females | 0.5 | 39.5 | 14.0 | 2.5 | 0.5 | --- | | | | | 114 |
| Combined | 0.3 | 39.5 | 42.7 | 15.9 | 1.3 | --- | 0.3 | | | | 309 |

**1982**

| YEAR CLASS | 1981 | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGE | I | II | III | IV | V | VI | VII | VIII | IX | X | N |
| **Spring** | | | | | | | | | | | |
| Males | | 2.4 | 36.2 | 9.1 | 1.2 | 0.3 | 0.3 | --- | 0.0 | | 166 |
| Females | | 1.8 | 39.8 | 3.6 | 3.6 | 0.9 | 0.3 | --- | 0.3 | | 168 |
| Combined | | 4.0 | 76.2 | 13.8 | 4.6 | 0.9 | 0.3 | --- | 0.2 | | 581 |
| **Early Summer** | | | | | | | | | | | |
| Males | | 4.3 | 31.0 | 3.9 | 0.0 | | 0.0 | --- | 0.0 | | 192 |
| Females | | 14.5 | 41.5 | 2.2 | 1.8 | | 0.6 | --- | 0.2 | | 299 |
| Combined | | 19.2 | 70.4 | 7.5 | 2.2 | 0.1 | 0.5 | --- | 0.1 | | 776 |
| **Late Summer** | | | | | | | | | | | |
| Males | 0.0 | 11.8 | 30.1 | 3.7 | 0.0 | 0.0 | | | | | 62 |
| Females | 0.7 | 27.2 | 19.1 | 1.5 | 5.1 | 0.7 | | | | | 74 |
| Combined | 0.8 | 35.2 | 49.8 | 9.9 | 3.6 | 0.4 | 0.4 | | | | 253 |
| **Fall** | | | | | | | | | | | |
| Males | | 8.7 | 17.4 | 4.3 | | | | | | | 7 |
| Females | | 13.0 | 39.1 | 17.4 | | | | | | | 16 |
| Combined | | 36.4 | 45.5 | 14.1 | 3.0 | 1.0 | | | | | 99 |
| **Seasons Combined** | | | | | | | | | | | |
| Males | 0.0 | 4.8 | 32.3 | 5.7 | 0.4 | 0.1 | 0.1 | --- | 0.0 | | 427 |
| Females | 0.1 | 11.9 | 37.8 | 2.9 | 2.8 | 0.4 | 0.4 | --- | 0.2 | | 557 |
| Combined | 0.1 | 17.4 | 67.9 | 10.3 | 3.2 | 0.5 | 0.4 | --- | 0.1 | | 1725 |

**1983**

| YEAR CLASS | 1982 | 1981 | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGE | I | II | III | IV | V | VI | VII | VIII | IX | X | N |
| **Spring** | | | | | | | | | | | |
| Males | | 5.1 | 7.9 | 10.2 | 2.8 | 0.0 | | | | | 56 |
| Females | | 22.3 | 22.8 | 20.9 | 6.0 | 1.9 | | | | | 159 |
| Combined | | 32.1 | 30.5 | 27.3 | 7.9 | 1.9 | 0.3 | | | | 315 |
| **Early Summer** | | | | | | | | | | | |
| Males | | 10.7 | 8.8 | 7.4 | 0.0 | 0.0 | | 0.0 | | | 73 |
| Females | | 41.9 | 17.6 | 8.8 | 2.6 | 1.5 | | 0.7 | | | 199 |
| Combined | | 49.3 | 26.7 | 19.6 | 2.0 | 1.7 | 0.2 | 0.5 | | | 404 |
| **Late Summer** | | | | | | | | | | | |
| Males | 2.8 | 27.8 | 8.3 | 1.4 | | | | | | | 29 |
| Females | 0.0 | 55.6 | 2.8 | 1.4 | | | | | | | 43 |
| Combined | 2.2 | 79.3 | 13.0 | 5.4 | | | | | | | 92 |
| **Fall** | | | | | | | | | | | |
| Males | 1.5 | 34.8 | 3.0 | 0.0 | --- | 1.5 | | | | | 27 |
| Females | 0.0 | 53.0 | 1.5 | 3.0 | --- | 1.5 | | | | | 39 |
| Combined | 1.1 | 86.2 | 7.4 | 3.2 | --- | 2.1 | | | | | 94 |
| **Seasons Combined** | | | | | | | | | | | |
| Males | 0.5 | 13.3 | 7.8 | 6.9 | 1.0 | 0.2 | | 0.0 | | | 185 |
| Females | 0.0 | 37.9 | 16.0 | 11.5 | 3.2 | 1.4 | | 0.3 | | | 440 |
| Combined | 0.3 | 50.2 | 24.6 | 19.1 | 3.6 | 1.7 | 0.2 | 0.2 | | | 905 |

Table 3.2.1-28. Seasonal age composition (%) of yellow perch in commercial gill net catches, Long Point Bay, Lake Erie (1975-1983).

| | | AGE | | | | | | |
|---|---|---|---|---|---|---|---|---|
| YEAR | SEASON | II | III | IV | V | VI | VII | VIII |
| 1975 | Spring | 0.8 | 7.5 | 80.0 | 10.0 | 1.7 | | |
| | Summer | 37.8 | 30.1 | 26.8 | 4.8 | 0.5 | | |
| | Fall | 78.3 | 18.3 | 3.3 | | | | |
| 1976 | Spring | 0.8 | 74.9 | 14.3 | 9.2 | 0.8 | | |
| | Summer | 13.3 | 62.2 | 20.0 | 4.5 | | | |
| | Fall | 63.8 | 28.6 | 1.7 | | | | |
| 1977 | Spring | 5.3 | 62.0 | 29.3 | 2.9 | | 0.5 | |
| | Summer | 81.7 | 13.7 | 4.2 | 0.4 | | | |
| | Fall | 90.3 | 7.6 | 0.9 | 0.8 | | | |
| 1978 | Spring | 1.2 | 66.0 | 18.9 | 10.1 | 1.9 | 1.9 | |
| | Summer | 42.7 | 43.7 | 11.1 | | 0.5 | | |
| | Fall | 75.0 | 25.0 | | | | | |
| 1979 | Spring | 7.7 | 39.2 | 41.2 | 8.2 | 2.1 | 0.8 | 0.6 |
| | Summer | | | | | | | |
| | Fall | 90.7 | 7.5 | 1.5 | 0.2 | | | |
| 1980 | Spring | 0.6 | 63.2 | 25.1 | 7.5 | 1.0 | 1.5 | 0.6 |
| | Summer | | | | | | | |
| | Fall | 60.2 | 27.4 | 1.7 | 0.4 | 0.1 | | |
| 1981 | Spring | 0.5 | 23.5 | 68.0 | 7.4 | 0.5 | 0.2 | |
| | Summer | 12.2 | 37.3 | 47.8 | 2.4 | 0.2 | | |
| | Fall | 59.5 | 25.8 | 14.3 | 0.2 | | | |
| 1982 | Spring | 1.5 | 38.2 | 32.9 | 24.9 | 2.4 | 0.1 | 0.1 |
| | Summer | 6.9 | 58.9 | 25.1 | 8.9 | 0.2 | | |
| | Fall | 31.3 | 61.8 | 5.9 | 0.9 | | | |
| 1983 | Spring | | 22.6 | 54.2 | 17.1 | 6.0 | 0.2 | |
| | Summer | 4.4 | 33.8 | 49.0 | 11.5 | 1.4 | | |
| | Fall | 34.1 | 37.4 | 26.0 | 2.5 | | | |

Table 3.2.1-29 Age composition (%) of rock bass in Nanticoke (8- and 10-ft nets pooled) trapnet catches, Long Point Bay, Lake Erie (1980-1983).

**1980**

| YEAR CLASS | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | 1970 | 1969 | N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGE | II | III | IV | V | VI | VII | VIII | IX | X | XI | |
| **Spring** | | | | | | | | | | | |
| Males | | 0.2 | 1.2 | 7.6 | 11.7 | 19.0 | 13.5 | 6.2 | 0.9 | 0.2 | 264 |
| Females | | 0.2 | 1.2 | 3.7 | 8.0 | 12.4 | 9.2 | 4.4 | 0.5 | 0.0 | 172 |
| Combined | | 0.9 | 2.3 | 11.2 | 19.6 | 31.3 | 22.6 | 10.5 | 1.4 | 0.2 | 430 |
| **Early Summer** | | | | | | | | | | | |
| Males | | 11.5 | 14.5 | 14.2 | 7.3 | 7.3 | 3.3 | 0.6 | 0.3 | | 195 |
| Females | | 7.0 | 9.4 | 9.1 | 6.3 | 5.1 | 3.6 | 0.6 | 0.0 | | 136 |
| Combined | | 18.9 | 23.7 | 23.1 | 13.5 | 12.3 | 6.9 | 1.2 | 0.3 | | 331 |
| **Late Summer** | | | | | | | | | | | |
| Males | 1.1 | 34.4 | 8.2 | 7.8 | 3.7 | 8.2 | 2.6 | | 0.4 | | 179 |
| Females | 0.0 | 16.3 | 5.6 | 5.6 | 3.3 | 1.9 | 1.1 | | 0.0 | | 91 |
| Combined | 1.8 | 52.8 | 12.9 | 12.6 | 6.6 | 9.4 | 3.5 | | 0.4 | | 286 |
| **Fall** | | | | | | | | | | | |
| Males | 1.8 | 19.2 | 7.5 | 12.8 | 8.2 | 5.3 | 5.3 | 0.4 | | | 170 |
| Females | 1.1 | 13.1 | 6.4 | 7.8 | 3.9 | 4.3 | 2.1 | 1.1 | | | 112 |
| Combined | 2.8 | 33.0 | 13.7 | 20.4 | 11.9 | 9.5 | 7.4 | 1.4 | | | 282 |
| **Seasons Combined** | | | | | | | | | | | |
| Males | 0.6 | 14.1 | 7.3 | 10.4 | 8.2 | 10.9 | 7.0 | 2.3 | 0.5 | 0.1 | 808 |
| Females | 0.2 | 8.0 | 5.2 | 6.3 | 5.8 | 6.7 | 4.6 | 1.8 | 0.2 | 0.0 | 511 |
| Combined | 1.0 | 23.3 | 12.3 | 16.4 | 13.7 | 17.3 | 11.4 | 4.0 | 0.6 | 0.1 | 1342 |

**1981**

| YEAR CLASS | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | 1970 | N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGE | II | III | IV | V | VI | VII | VIII | IX | X | XI | |
| **Spring** | | | | | | | | | | | |
| Males | | 3.5 | 32.3 | 3.0 | 3.5 | 4.0 | 1.5 | 1.5 | 0.5 | | 99 |
| Females | | 3.5 | 31.3 | 4.0 | 2.5 | 3.5 | 1.0 | 2.5 | 0.5 | | 97 |
| Combined | | 2.8 | 32.0 | 13.8 | 15.8 | 12.8 | 10.3 | 10.6 | 1.8 | 0.3 | 654 |
| **Early Summer** | | | | | | | | | | | |
| Males | 0.0 | 5.1 | 41.4 | 3.9 | 2.5 | 0.7 | 0.3 | 0.5 | 0.3 | | 323 |
| Females | 0.2 | 3.6 | 34.6 | 2.9 | 1.9 | 0.5 | 0.7 | 0.3 | 0.0 | | 263 |
| Combined | 0.1 | 8.5 | 65.5 | 9.6 | 8.4 | 2.5 | 3.0 | 2.1 | 0.3 | | 920 |
| **Late Summer** | | | | | | | | | | | |
| Males | 0.3 | 13.4 | 36.5 | 3.3 | 1.2 | 0.3 | 0.3 | 0.3 | | | 187 |
| Females | 0.3 | 13.1 | 26.1 | 2.4 | 1.2 | 0.0 | 0.3 | 0.3 | | | 147 |
| Combined | 0.5 | 22.8 | 60.1 | 9.9 | 3.6 | 1.2 | 1.2 | 0.7 | | | 416 |
| **Fall** | | | | | | | | | | | |
| Males | 1.1 | 12.2 | 41.5 | 4.6 | 3.2 | 1.3 | 0.8 | 0.2 | | | 308 |
| Females | 0.6 | 9.5 | 17.7 | 2.7 | 1.9 | 0.6 | 0.6 | 0.6 | | | 163 |
| Combined | 1.3 | 18.6 | 60.5 | 7.9 | 6.3 | 2.3 | 1.8 | 0.8 | 0.3 | | 617 |
| **Seasons Combined** | | | | | | | | | | | |
| Males | 0.4 | 8.8 | 39.3 | 3.9 | 2.6 | 1.2 | 0.6 | 0.5 | 0.2 | | 917 |
| Females | 0.3 | 7.3 | 27.4 | 2.9 | 1.8 | 0.8 | 0.6 | 0.7 | 0.1 | | 681 |
| Combined | 0.4 | 11.7 | 55.0 | 10.3 | 9.0 | 4.8 | 4.3 | 3.7 | 0.7 | 0.1 | 2607 |

**1982**

| YEAR CLASS | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGE | II | III | IV | V | VI | VII | VIII | IX | X | XI | |
| **Spring** | | | | | | | | | | | |
| Males | | 0.2 | 4.4 | 34.2 | 7.2 | 4.3 | 4.9 | 3.0 | 1.5 | 1.0 | 369 |
| Females | | 0.2 | 3.1 | 24.0 | 3.3 | 3.0 | 3.5 | 1.3 | 0.8 | 0.0 | 238 |
| Combined | | 0.3 | 7.8 | 56.9 | 12.0 | 7.6 | 8.0 | 4.0 | 2.5 | 1.1 | 1044 |
| **Early Summer** | | | | | | | | | | | |
| Males | | 0.8 | 20.7 | 32.9 | 1.7 | 0.8 | 0.6 | 0.3 | 0.3 | | 210 |
| Females | | 1.7 | 15.5 | 18.5 | 2.8 | 1.4 | 1.4 | 0.6 | 0.3 | | 153 |
| Combined | | 2.4 | 31.5 | 55.6 | 5.4 | 2.6 | 1.5 | 0.7 | 0.3 | | 737 |
| **Late Summer** | | | | | | | | | | | |
| Males | | 5.8 | 25.4 | 22.0 | 1.2 | 1.7 | 0.0 | --- | | | 97 |
| Females | | 1.7 | 16.8 | 19.7 | 4.1 | 1.2 | 0.6 | --- | | | 76 |
| Combined | 0.9 | 6.7 | 41.9 | 42.2 | 4.3 | 2.5 | 1.2 | --- | 0.3 | | 327 |
| **Fall** | | | | | | | | | | | |
| Males | 1.4 | 5.7 | 32.1 | 27.9 | 3.6 | 0.7 | 1.4 | | | | 102 |
| Females | 0.7 | 1.4 | 10.0 | 10.7 | 1.4 | 1.4 | 0.7 | | | | 37 |
| Combined | 3.2 | 10.1 | 34.0 | 42.1 | 5.7 | 1.9 | 2.2 | 0.6 | | | 318 |
| **Seasons Combined** | | | | | | | | | | | |
| Males | 0.2 | 1.9 | 15.4 | 31.7 | 4.6 | 2.5 | 2.5 | 1.4 | 0.8 | | 847 |
| Females | 0.1 | 0.9 | 9.1 | 20.0 | 3.1 | 2.2 | 2.1 | 0.7 | 0.4 | | 535 |
| Combined | 0.6 | 3.2 | 23.3 | 52.4 | 8.2 | 4.6 | 4.2 | 1.9 | 1.2 | 0.4 | 2527 |

**1983**

| YEAR CLASS | 1981 | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGE | II | III | IV | V | VI | VII | VIII | IX | X | XI | |
| **Spring** | | | | | | | | | | | |
| Males | | 0.1 | 2.3 | 21.1 | 33.5 | 3.4 | 1.1 | 0.9 | 0.4 | 0.1 | 469 |
| Females | | 0.0 | 1.5 | 10.2 | 20.4 | 1.7 | 1.5 | 0.9 | 0.8 | 0.1 | 277 |
| Combined | | 0.1 | 4.8 | 31.6 | 53.0 | 4.6 | 2.7 | 1.9 | 1.2 | 0.2 | 1045 |
| **Early Summer** | | | | | | | | | | | |
| Males | | 2.0 | 8.0 | 27.6 | 17.6 | 1.0 | 0.5 | 0.0 | 0.0 | | 116 |
| Females | | 2.5 | 7.5 | 11.6 | 15.1 | 1.0 | 3.0 | 1.5 | 1.0 | | 81 |
| Combined | | 3.1 | 14.4 | 40.1 | 35.1 | 1.9 | 2.5 | 1.3 | 1.6 | | 319 |
| **Late Summer** | | | | | | | | | | | |
| Males | | 4.9 | 11.1 | 18.5 | 32.1 | 4.9 | 1.2 | --- | 0.0 | | 59 |
| Females | | 1.2 | 6.2 | 8.6 | 4.9 | 1.2 | 3.7 | --- | 1.2 | | 22 |
| Combined | | 7.3 | 15.8 | 29.7 | 34.6 | 4.9 | 4.2 | --- | 3.0 | 0.6 | 165 |
| **Fall** | | | | | | | | | | | |
| Males | 0.3 | 3.4 | 11.6 | 20.9 | 30.5 | 0.0 | 1.0 | 0.7 | 1.4 | 0.3 | 213 |
| Females | 0.0 | 2.7 | 4.5 | 8.2 | 9.3 | 2.7 | 1.0 | 0.3 | 1.0 | 0.0 | 79 |
| Combined | 0.5 | 6.4 | 14.7 | 32.4 | 37.8 | 3.0 | 2.2 | 0.7 | 2.0 | 0.3 | 407 |
| **Seasons Combined** | | | | | | | | | | | |
| Males | 0.1 | 1.4 | 5.8 | 21.9 | 30.4 | 3.0 | 1.0 | 0.9 | 0.5 | 0.2 | 857 |
| Females | 0.0 | 1.1 | 3.3 | 9.9 | 16.2 | 1.2 | 1.8 | 0.6 | 0.9 | 0.1 | 461 |
| Combined | 0.1 | 2.5 | 9.4 | 33.0 | 45.3 | 3.8 | 2.7 | 1.4 | 1.6 | 0.2 | 1936 |

Table 3.2.1-30 Age composition (%) of rock bass in Centre Creek (6-ft nets pooled) trapnet catches, Long Point Bay, Lake Erie (1980-1983).

**1980**

| YEAR CLASS | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | 1970 | 1969 | N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGE | II | III | IV | V | VI | VII | VIII | IX | X | XI | |
| **Spring** | | | | | | | | | | | |
| Males | | 4.0 | 2.7 | 9.4 | 10.4 | 20.1 | 8.0 | 5.4 | 0.7 | 0.0 | 183 |
| Females | | 3.3 | 3.7 | 5.0 | 5.4 | 9.0 | 7.7 | 4.4 | 0.3 | 0.7 | 116 |
| Combined | | 8.0 | 6.3 | 14.3 | 15.6 | 28.9 | 15.6 | 9.6 | 1.0 | 0.7 | 301 |
| **Early Summer** | | | | | | | | | | | |
| Males | 0.0 | 25.5 | 18.3 | 9.4 | 2.7 | 3.6 | 0.9 | 0.0 | | | 136 |
| Females | 1.3 | 17.4 | 9.8 | 4.5 | 2.2 | 2.2 | 1.8 | 0.5 | | | 88 |
| Combined | 1.3 | 45.1 | 27.2 | 13.2 | 4.7 | 5.5 | 2.6 | 0.4 | | | 235 |
| **Late Summer** | | | | | | | | | | | |
| Males | 4.2 | 47.2 | 5.6 | 1.4 | 0.0 | 1.4 | 0.0 | | | | 43 |
| Females | 1.4 | 33.3 | 2.8 | 0.0 | 1.4 | 0.0 | 1.4 | | | | 29 |
| Combined | 5.5 | 80.8 | 8.2 | 1.4 | 1.4 | 1.4 | 1.4 | | | | 73 |
| **Fall** | | | | | | | | | | | |
| Males | 0.0 | 19.1 | 10.1 | 5.6 | 3.4 | 15.7 | 5.6 | 2.3 | | | 55 |
| Females | 1.1 | 14.6 | 3.4 | 1.1 | 7.9 | 3.4 | 4.5 | 2.3 | | | 34 |
| Combined | 1.1 | 33.3 | 14.4 | 6.7 | 11.1 | 18.9 | 10.0 | 4.4 | | | 90 |
| **Seasons Combined** | | | | | | | | | | | |
| Males | 0.4 | 17.5 | 9.1 | 8.0 | 5.9 | 12.1 | 4.5 | 2.8 | 0.3 | 0.0 | 407 |
| Females | 0.7 | 12.6 | 5.6 | 3.8 | 4.2 | 5.1 | 4.7 | 2.2 | 0.1 | 0.3 | 267 |
| Combined | 1.1 | 31.3 | 14.6 | 11.6 | 9.9 | 16.9 | 9.0 | 4.9 | 0.4 | 0.3 | 699 |

**1981**

| YEAR CLASS | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | 1970 | N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGE | II | III | IV | V | VI | VII | VIII | IX | X | XI | |
| **Spring** | | | | | | | | | | | |
| Males | | | | | | | | | | | |
| Females | | | | | | | | | | | |
| Combined | | 13.6 | 47.7 | 4.6 | 13.6 | 6.8 | 6.8 | 4.6 | 2.3 | | 44 |
| **Early Summer** | | | | | | | | | | | |
| Males | | 6.9 | 55.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | 45 |
| Females | | 5.6 | 25.0 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | | | 27 |
| Combined | | 8.4 | 80.4 | 3.7 | 3.7 | 0.9 | 0.9 | 1.9 | | | 107 |
| **Late Summer** | | | | | | | | | | | |
| Males | | 8.3 | 33.3 | --- | --- | --- | --- | 4.2 | | | 11 |
| Females | | 29.2 | 25.0 | --- | --- | --- | --- | 0.0 | | | 13 |
| Combined | 2.6 | 26.3 | 68.4 | --- | --- | --- | --- | 2.6 | | | 38 |
| **Fall** | | | | | | | | | | | |
| Males | 2.8 | 2.8 | 50.0 | 0.0 | 0.0 | | 0.0 | | | | 21 |
| Females | 0.0 | 13.9 | 22.2 | 2.8 | 2.8 | | 2.8 | | | | 15 |
| Combined | 2.2 | 15.6 | 71.1 | 2.2 | 4.4 | 2.2 | 2.2 | | | | 45 |
| **Seasons Combined** | | | | | | | | | | | |
| Males | 0.7 | 9.4 | 48.6 | 0.7 | 0.0 | 0.0 | 0.0 | 0.7 | | | 83 |
| Females | 0.0 | 11.6 | 23.2 | 0.7 | 1.5 | 0.7 | 1.5 | 0.7 | | | 55 |
| Combined | 0.9 | 13.7 | 70.5 | 3.0 | 5.1 | 2.1 | 2.1 | 2.1 | 0.4 | | 234 |

**1982**

| YEAR CLASS | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGE | II | III | IV | V | VI | VII | VIII | IX | X | XI | |
| **Spring** | | | | | | | | | | | |
| Males | | 0.3 | 8.4 | 36.5 | 5.7 | 2.1 | 3.0 | 2.4 | 1.2 | 0.3 | 200 |
| Females | | 0.0 | 5.7 | 24.6 | 3.0 | 2.1 | 1.8 | 2.7 | 0.0 | 0.3 | 134 |
| Combined | | 1.4 | 16.8 | 60.8 | 7.2 | 3.1 | 4.9 | 4.0 | 1.5 | 0.5 | 655 |
| **Early Summer** | | | | | | | | | | | |
| Males | | 4.2 | 29.4 | 24.9 | 1.3 | 1.1 | 1.1 | 0.3 | 0.0 | | 199 |
| Females | | 1.3 | 18.3 | 14.6 | 1.3 | 0.8 | 0.3 | 0.8 | 0.5 | | 141 |
| Combined | 0.1 | 8.5 | 46.9 | 38.3 | 2.2 | 1.9 | 0.9 | 0.9 | 0.4 | | 695 |
| **Late Summer** | | | | | | | | | | | |
| Males | | 8.0 | 31.2 | 24.8 | 2.4 | 1.6 | | | | | 85 |
| Females | | 2.4 | 18.4 | 10.4 | 0.0 | 0.0 | | | | | 39 |
| Combined | 0.8 | 13.8 | 51.2 | 30.7 | 2.0 | 1.2 | | | | | 254 |
| **Fall** | | | | | | | | | | | |
| Males | | 6.7 | 26.7 | 40.0 | 2.2 | 6.7 | 0.0 | | | | 37 |
| Females | | 0.0 | 4.4 | 6.7 | 0.0 | 4.4 | 2.2 | | | | 8 |
| Combined | 2.0 | 8.4 | 38.3 | 42.2 | 3.9 | 3.9 | 1.3 | | | | 154 |
| **Seasons Combined** | | | | | | | | | | | |
| Males | | 3.4 | 21.5 | 30.1 | 3.2 | 1.8 | 1.6 | 1.0 | 0.7 | 0.1 | 559 |
| Females | | 0.9 | 12.8 | 17.4 | 1.7 | 1.4 | 0.9 | 1.4 | 0.0 | 0.1 | 322 |
| Combined | 0.3 | 6.6 | 35.6 | 45.9 | 4.2 | 2.4 | 2.3 | 1.8 | 0.7 | 0.2 | 1758 |

**1983**

| YEAR CLASS | 1981 | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AGE | II | III | IV | V | VI | VII | VIII | IX | X | XI | |
| **Spring** | | | | | | | | | | | |
| Males | | | 2.4 | 21.0 | 30.5 | 2.1 | 0.3 | 0.9 | 1.5 | 0.3 | 194 |
| Females | | | 1.8 | 13.4 | 22.0 | 1.2 | 1.2 | 0.3 | 0.9 | 0.0 | 134 |
| Combined | | 0.2 | 4.8 | 36.1 | 51.9 | 2.7 | 1.2 | 0.8 | 2.1 | 0.2 | 518 |
| **Early Summer** | | | | | | | | | | | |
| Males | | 1.4 | 18.8 | 26.0 | 13.3 | 0.3 | 0.3 | 0.0 | 0.0 | | 221 |
| Females | | 1.9 | 6.4 | 16.1 | 13.0 | 1.1 | 0.6 | 0.6 | 0.3 | | 140 |
| Combined | | 2.4 | 23.4 | 42.0 | 29.7 | 1.1 | 0.7 | 0.6 | 0.2 | | 543 |
| **Late Summer** | | | | | | | | | | | |
| Males | 0.0 | 8.3 | 36.1 | 23.6 | 6.9 | --- | | | | | 54 |
| Females | 2.8 | 2.8 | 4.2 | 9.7 | 5.6 | --- | | | | | 18 |
| Combined | 3.4 | 7.7 | 37.6 | 32.5 | 18.0 | --- | 0.9 | | | | 117 |
| **Fall** | | | | | | | | | | | |
| Males | 0.6 | 4.3 | 13.4 | 26.2 | 21.3 | 1.8 | 0.0 | 1.8 | 0.0 | | 117 |
| Females | 0.6 | 1.8 | 3.7 | 13.4 | 7.3 | 0.6 | 0.6 | 0.6 | 1.2 | | 46 |
| Combined | 1.0 | 6.2 | 18.1 | 37.3 | 31.1 | 2.1 | 0.5 | 2.1 | 1.0 | | 193 |
| **Seasons Combined** | | | | | | | | | | | |
| Males | 0.1 | 2.0 | 13.4 | 24.1 | 20.3 | 1.5 | 0.3 | 0.7 | 0.9 | 0.1 | 586 |
| Females | 0.3 | 1.3 | 4.1 | 14.2 | 14.6 | 0.7 | 0.7 | 0.4 | 0.3 | 0.0 | 342 |
| Combined | 0.4 | 2.6 | 16.9 | 38.3 | 37.3 | 1.8 | 0.9 | 0.8 | 1.0 | 0.1 | 1371 |

Table 3.2.1-31. Seasonal levels (range and mean ± SD) of secchi transparency and water temperature recorded at Nanticoke and Centre Creek trapnet locations, 1980-1983.[1]

| SEASON | STATISTIC | LOCATION | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | PEACOCK POINT | ONEIDA | EAST[2] PLUME | WEST PLUME | EAST BROWN'S PT. | WEST BROWN'S PT. | EAST CENTRE CK. | WEST CENTRE CK. |
| | | **Seechi (m)** | | | | | | | |
| Spring | Range | 0.5-3.0 | 0.5-3.5 | 0.5-2.7 | 0.5-3.0 | 0.5-3.0 | 0.5-3.5 | 0.3-3.0 | 0.3-3.0 |
| | Mean | 1.7 | 1.9 | 1.5 | 1.6 | 1.6 | 1.7 | 1.3 | 1.3 |
| | SD | 0.8 | 0.8 | 0.7 | 0.7 | 0.7 | 0.9 | 0.7 | 0.8 |
| | N | 29 | 31 | 18 | 31 | 31 | 28 | 26 | 24 |
| Early Summer | Range | 0.8-4.0 | 1.0-4.0 | 1.2-3.0 | 1.0-4.5 | 0.8-5.0 | 0.5-4.0 | 0.2-3.0 | 0.2-3.5 |
| | Mean | 1.9 | 2.1 | 1.9 | 2.0 | 2.0 | 2.0 | 1.4 | 1.5 |
| | SD | 0.9 | 0.7 | 0.5 | 0.7 | 0.9 | 0.8 | 0.8 | 0.8 |
| | N | 45 | 48 | 25 | 49 | 48 | 45 | 44 | 42 |
| Late Summer | Range | 0.3-5.0 | 0.3-3.5 | 0.3-3.2 | 0.3-4.0 | 0-4.0 | 0.5-5.0 | 0.3-2.5 | 0.3-3.0 |
| | Mean | 2.0 | 2.0 | 1.8 | 1.9 | 1.8 | 2.3 | 1.1 | 1.3 |
| | SD | 0.9 | 0.8 | 0.7 | 0.8 | 1.1 | 1.2 | 0.7 | 0.7 |
| | N | 43 | 43 | 22 | 40 | 40 | 38 | 34 | 32 |
| Fall | Range | 0.5-4.2 | 0.5-4.5 | 0.5-3.5 | 0.5-4.0 | 0.5-5.2 | 0.5-4.0 | 0.2-3.0 | 0.2-3.0 |
| | Mean | 1.6 | 1.6 | 1.6 | 1.6 | 1.5 | 1.7 | 1.1 | 1.1 |
| | SD | 0.8 | 0.7 | 0.8 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 |
| | N | 47 | 51 | 25 | 48 | 49 | 45 | 41 | 38 |
| All Seasons | Range | 0.3-5.0 | 0.3-4.5 | 0.3-3.5 | 0.3-4.5 | 0.0-5.2 | 0.5-5.0 | 0.2-3.0 | 0.2-3.5 |
| | Mean | 1.8 | 1.9 | 1.7 | 1.8 | 1.7 | 2.0 | 1.3 | 1.3 |
| | SD | 0.8 | 0.8 | 0.7 | 0.7 | 0.9 | 1.0 | 0.7 | 0.8 |
| | N | 164 | 173 | 90 | 168 | 168 | 156 | 145 | 136 |
| | | **Water Temperature (°C)** | | | | | | | |
| Spring | Range | 6.9-15.2 | 5.8-15.2 | 7.3-15.5 | 6.3-15.3 | 5.4-14.9 | 5.6-14.5 | 7.5-16.0 | 8.0-15.8 |
| | Mean | 10.3 | 9.9 | 11.7 | 10.3 | 9.7 | 9.7 | 11.1 | 11.2 |
| | SD | 2.3 | 2.3 | 2.2 | 2.4 | 2.4 | 2.3 | 2.1 | 2.1 |
| | N | 25 | 29 | 19 | 30 | 28 | 25 | 21 | 21 |
| Early Summer | Range | 9.3-21.1 | 8.8-21.1 | 10.5-20.9 | 8.1-22.0 | 7.1-21.2 | 6.6-21.1 | 8.4-22.0 | 8.6-22.0 |
| | Mean | 14.9 | 14.6 | 15.2 | 15.2 | 14.6 | 14.4 | 15.8 | 15.7 |
| | SD | 3.4 | 3.5 | 2.8 | 3.7 | 3.6 | 3.5 | 3.4 | 3.6 |
| | N | 45 | 47 | 26 | 46 | 48 | 43 | 43 | 41 |
| Late Summer | Range | 16.3-25.0 | 17.6-24.0 | 18.4-24.1 | 17.9-24.3 | 17.8-24.2 | 17.7-24.0 | 16.5-24.0 | 16.0-24.0 |
| | Mean | 21.5 | 21.3 | 21.3 | 21.8 | 21.2 | 21.1 | 21.0 | 20.7 |
| | SD | 2.0 | 1.8 | 1.7 | 1.7 | 1.8 | 1.7 | 1.8 | 2.0 |
| | N | 43 | 43 | 22 | 40 | 40 | 38 | 33 | 30 |
| Fall | Range | 6.0-24.6 | 6.3-24.0 | 12.0-24.3 | 6.3-24.4 | 6.0-24.0 | 5.3-24.0 | 9.0-23.0 | 9.0-22.5 |
| | Mean | 15.8 | 16.1 | 18.5 | 17.1 | 16.0 | 16.1 | 15.5 | 15.5 |
| | SD | 4.7 | 4.5 | 3.1 | 4.1 | 4.4 | 4.4 | 4.0 | 3.7 |
| | N | 48 | 52 | 25 | 49 | 51 | 48 | 39 | 37 |
| All Seasons | Range | 6.0-25.0 | 5.8-24.0 | 7.3-24.3 | 6.3-24.4 | 5.4-24.2 | 5.3-24.0 | 7.5-24.0 | 8.0-24.0 |
| | Mean | 16.2 | 16.0 | 16.8 | 16.5 | 15.8 | 15.8 | 16.3 | 16.1 |
| | SD | 5.0 | 5.0 | 4.3 | 5.0 | 5.0 | 5.0 | 4.4 | 4.3 |
| | N | 161 | 171 | 92 | 165 | 167 | 154 | 136 | 136 |

[1] Temperature data are an average of water column except for east and west Centre Creek, which are surface temperatures.

[2] Data are for 1982-1983 only.

Table 3.2.1-32. Bottom sediment and vegetation features near Nanticoke and Centre Creek trapnet locations.

| TRAP NET LOCATION | BOTTOM ELEVATION | MINIMUM SEDIMENT THICKNESS OVERLYING BEDROCK (cm) | SEDIMENT COMPOSITION[2] | | | SUBMERGED VEGETATION | | |
|---|---|---|---|---|---|---|---|---|
| | | | Boulder & Cobble (>6.4) | Pebble & Gravel (0.2 - 6.4 cm) | Sand & Mud (<0.2 cm) | % Bottom Coverage | Predominate Type | Approx. Average Ht. (cm) |
| Peacock Point | flat | <5 | 15 | 10 | 75 | < 5 | filamentous algae | 1-2 |
| Oneida | flat | >5 | 20 | 15 | 65 | 25 | filamentous algae | 2-4 |
| East Plume | flat | >5 | 0 | 0 | 100 | 0 | | |
| West Plume | flat | >5 | 0 | 0 | 100 | 0 | | |
| East Brown's Point | variable | <5 | 35 | 5 | 60 | 10 | filamentous algae | 15 |
| West Brown's Point | flat | <5 | 10 | < 5 | 90 | 20 | filamentous algae | 1-2 |
| East Centre Creek | variable | <5 | 15 | < 5 | 85 | 20 | filamentous algae | 1-2 |
| West Centre Creek | flat | <5 | 15 | < 5 | 85 | 20 | filamentous algae | 1-2 |

[1] Data are approximations based on visual observations with scuba in July - August, 1985.

[2] Percent coverage of total bottom surface, including areas of bedrock covered by fine sediment.

Table 3.2.1-33. Correlations of environmental variables with mean catch ($\log_{10}$ x + 1) per lift of yellow perch, rock bass, and all fish in Nanticoke trap nets, 1980-1983. Correlation coefficients are summarized by season with sample sizes (N) given in brackets.

| ENVIRONMENTAL VARIABLE | SPRING (N = 33-36) | | | EARLY SUMMER (N = 50) | | | LATE SUMMER (N = 45) | | | FALL (N = 54-55) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Y. Perch | R. Bass | All Fish | Y. Perch | R. Bass | All Fish | Y. Perch | R. Bass | All Fish | Y. Perch | R. Bass | All Fish |
| WATER TEMP. | | | | | | | | | | | | |
| Surface | $-0.560^{c}$ | 0.149 | -0.245 | $-0.625^{d}$ | -0.145 | $-0.509^{c}$ | 0.045 | -0.203 | 0.054 | -0.243 | 0.049 | 0.155 |
| Bottom | $-0.548^{c}$ | 0.154 | -0.184 | $-0.498^{c}$ | -0.035 | $-0.376^{b}$ | 0.100 | -0.147 | 0.182 | -0.235 | 0.024 | 0.146 |
| Mean | $-0.607^{c}$ | 0.183 | -0.232 | $-0.557^{d}$ | -0.090 | $-0.448^{b}$ | 0.064 | -0.199 | 0.094 | -0.241 | 0.036 | 0.151 |
| WIND SPEED | | | | | | | | | | | | |
| Mean | 0.032 | 0.122 | 0.236 | $0.374^{b}$ | 0.096 | $0.412^{b}$ | 0.128 | 0.105 | 0.063 | 0.173 | 0.168 | 0.114 |
| Maximum | 0.167 | 0.008 | 0.232 | $0.349^{a}$ | 0.274 | $0.525^{d}$ | 0.205 | 0.187 | 0.215 | $0.313^{a}$ | 0.218 | 0.242 |
| WIND DIRECTION | | | | | | | | | | | | |
| Most freq. | 0.139 | 0.083 | 0.148 | -0.124 | 0.113 | 0.051 | 0.209 | 0.056 | 0.020 | 0.009 | 0.214 | 0.089 |
| At Max. Wind Speed | -0.144 | 0.186 | 0.149 | 0.132 | -0.041 | 0.093 | 0.199 | -0.041 | -0.016 | -0.182 | 0.251 | 0.048 |
| WAVE INDEX | | | | | | | | | | | | |
| Mean | 0.096 | 0.141 | 0.200 | 0.023 | 0.138 | 0.200 | 0.222 | 0.092 | 0.048 | 0.066 | 0.236 | 0.117 |
| At Max. Wind Speed | -0.124 | 0.195 | 0.193 | 0.252 | 0.030 | 0.247 | 0.264 | 0.047 | 0.068 | -0.086 | $0.292^{a}$ | 0.116 |
| SECCHI | $-0.534^{b}$ | $-0.471^{b}$ | -0.170 | -0.182 | -0.165 | $-0.334^{a}$ | -0.293 | -0.201 | $-0.508^{c}$ | 0.064 | -0.129 | 0.042 |

a = significant at P = 0.05; b = significant at P = 0.01; c = significant at P = 0.001; d = significant at P = 0.0001.

Table 3.2.1-34. Correlations of environmental variables with mean catch ($\log_{10} x + 1$) per lift of yellow perch, rock bass, and all fish in Centre Creek trap nets, 1980-1983. Correlation coefficients are summarized by season with sample sizes (N) given in brackets.

| ENVIRONMENTAL VARIABLE | SPRING (N = 17-34) | | | EARLY SUMMER (N =29 - 52) | | | LATE SUMMER (N = 31-42) | | | FALL (N = 38-55) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Y. Perch | R. Bass | All Fish | Y. Perch | R. Bass | All Fish | Y. Perch | R. Bass | All Fish | Y. Perch | R. Bass | All Fish |
| WATER TEMP. | | | | | | | | | | | | |
| Surface | 0.103 | 0.320 | 0.117 | $-0.383^b$ | -0.189 | -0.287 | -0.217 | $-0.375^a$ | $-0.374^a$ | $0.461^b$ | 0.250 | 0.261 |
| Bottom | 0.082 | 0.349 | 0.259 | $-0.705^d$ | $-0.654^d$ | $-0.720^d$ | $-0.410^a$ | $-0.420^a$ | $-0.510^b$ | $0.469^b$ | 0.292 | 0.145 |
| Mean | 0.041 | 0.353 | 0.066 | $-0.654^d$ | $-0.536^b$ | $-0.629^c$ | $-0.385^a$ | $-0.396^a$ | $-0.486^b$ | $0.441^b$ | 0.239 | 0.310 |
| WIND SPEED | | | | | | | | | | | | |
| Mean | -0.304 | -0.146 | -0.213 | -0.114 | -0.255 | -0.213 | $0.620^d$ | 0.036 | $0.491^b$ | -0.251 | -0.157 | -0.133 |
| Maximum | $-0.347^a$ | -0.193 | -0.289 | -0.115 | $-0.322^a$ | -0.260 | $0.443^b$ | -0.200 | 0.224 | $-0.362^b$ | -0.202 | $-0.266^a$ |
| WIND DIRECTION | | | | | | | | | | | | |
| Most freq. | -0.077 | -0.022 | -0.021 | 0.104 | 0.225 | 0.149 | $0.325^a$ | $0.352^a$ | $0.388^a$ | -0.055 | 0.241 | 0.100 |
| At Max. Wind Speed | 0.140 | $0.344^a$ | 0.281 | 0.218 | 0.129 | 0.153 | 0.283 | -0.020 | 0.197 | -0.170 | 0.171 | 0.023 |
| WAVE INDEX | | | | | | | | | | | | |
| Mean | -0.191 | -0.049 | -0.083 | 0.051 | 0.099 | 0.050 | $0.451^b$ | $0.309^a$ | $0.439^b$ | -0.163 | 0.120 | 0.014 |
| At Max. Wind Speed | 0.042 | 0.318 | 0.223 | 0.161 | 0.025 | 0.066 | $0.413^b$ | -0.100 | 0.245 | -0.265 | 0.081 | -0.072 |
| SECCHI | $0.539^b$ | -0.054 | 0.038 | 0.050 | 0.116 | 0.082 | 0.249 | 0.109 | 0.263 | $0.376^a$ | 0.133 | $0.348^a$ |

a = significant at P = 0.05; b = significant at P = 0.01; c = significant at P = 0.001; d = significant at P = 0.0001.

Table 3.2.1-35. Regression equations for predicting mean catch ($\log_{10}$ x + 1/lift) of all fish, yellow perch, and rock bass in Nanticoke and Centre Creek trap nets from selected environmental variables, 1980-1983.

| | | | | | | Fraction of $R^2$ Explained by Each Independent Variable* | | | |
|---|---|---|---|---|---|---|---|---|---|
| Season | EQ. NO. | Species - Equation+ | N | $R^2$ | P | Temp | Secchi | Wspd | Wdir |
| | | Nanticoke Trap Nets | | | | | | | |
| Spring | 1 | Log all fish = 1.089 - 0.233 secchi | 31 | 0.419 | 0.0001 | ---** | 0.419 | --- | --- |
| | 2 | Log y. perch = 2.489 - 0.072 temp - 0.079 secchi - 0.366 wspd - 0.023 wdir | 31 | 0.381 | 0.0116 | 0.297 | 0.025 | 0.034 | 0.025 |
| | 3 | Log r. bass = 0.692 + 0.080 temp - 0.325 secchi + 0.022 wdir | 31 | 0.384 | 0.0040 | 0.150 | 0.218 | — | 0.016 |
| Early Summer | 4 | Log all fish = 0.667 - 0.017 temp - 0.036 secchi + 0.472 wspd | 50 | 0.413 | 0.0001 | 0.124 | 0.014 | 0.275 | --- |
| | 5 | Log y. perch = 0.614 - 0.033 temp + 0.336 wspd | 50 | 0.370 | 0.0001 | 0.310 | --- | 0.060 | --- |
| | 6 | Log r. bass = 0.422 - 0.029 secchi + 0.265 wspd | 50 | 0.086 | 0.1223 | — | 0.010 | 0.075 | --- |
| Late Summer | 7 | Log all fish = 1.577 - 0.176 secchi | 45 | 0.258 | 0.0004 | — | 0.258 | — | --- |
| | 8 | Log y. perch = 0.546 - 0.080 secchi + 0.181 wspd + 0.020 wdir | 45 | 0.126 | 0.1333 | --- | 0.086 | 0.010 | 0.030 |
| | 9 | Log r. bass = 1.057 - 0.033 temp - 0.049 secchi + 0.292 wspd | 45 | 0.116 | 0.1649 | 0.047 | 0.023 | 0.045 | --- |
| Fall | 10 | Log all fish = 0.134 + 0.012 temp + 0.061 secchi + 0.493 wspd | 54 | 0.107 | 0.1274 | 0.045 | 0.013 | 0.048 | — |
| | 11 | Log y. perch = -0.037 - 0.016 temp + 0.150 secchi + 0.623 wspd - 0.029 wdir | 54 | 0.256 | 0.0052 | 0.064 | 0.057 | 0.090 | 0.045 |
| | 12 | Log r. bass = 0.128 + 0.236 wspd + 0.026 wdir | 54 | 0.083 | 0.1101 | --- | — | 0.034 | 0.049 |
| | | Centre Creek Trap Nets | | | | | | | |
| Spring | 13 | Log all fish = 1.345 + 0.021 temp + 0.059 wdir | 21 | 0.163 | 0.2016 | 0.015 | --- | — | 0.148 |
| | 14 | Log y. perch = 1.350 + 0.204 secchi - 0.364 wspd + 0.045 wdir | 21 | 0.308 | 0.0925 | — | 0.207 | 0.012 | 0.089 |
| | 15 | Log r. bass = 1.415 + 0.099 temp - 0.270 secchi - 0.834 wspd + 0.074 wdir | 21 | 0.271 | 0.2525 | 0.102 | 0.040 | 0.015 | 0.114 |
| Early Summer | 16 | Log all fish = 3.641 - 0.043 temp - 1.144 wspd + 0.023 wdir | 42 | 0.242 | 0.0136 | 0.098 | — | 0.133 | 0.011 |
| | 17 | Log y. perch = 2.860 - 0.059 temp - 0.791 wspd + 0.046 wdir | 42 | 0.237 | 0.0154 | 0.138 | --- | 0.062 | 0.037 |
| | 18 | Log r. bass = 2.976 - 0.025 temp - 1.068 wspd | 42 | 0.206 | 0.0111 | 0.042 | — | 0.164 | — |
| Late Summer | 19 | Log all fish = 1.931 - 0.073 temp + 0.082 secchi + 0.319 wspd + 0.042 wdir | 34 | 0.306 | 0.0272 | 0.183 | 0.018 | 0.018 | 0.086 |
| | 20 | Log y. perch = -0.093 - 0.052 temp + 0.155 secchi + 1.064 wspd + 0.051 wdir | 34 | 0.298 | 0.0315 | 0.047 | 0.105 | 0.116 | 0.029 |
| | 21 | Log r. bass = 2.839 - 0.074 temp - 0.584 wspd + 0.024 wdir | 34 | 0.205 | 0.0725 | 0.136 | — | 0.050 | 0.019 |
| Fall | 22 | Log all fish = 1.864 + 0.020 temp - 0.948 wspd + 0.042 wdir | 37 | 0.219 | 0.0403 | 0.059 | — | 0.134 | 0.059 |
| | 23 | Log y. perch = 0.016 + 0.032 temp + 0.109 secchi - 0.037 wdir | 37 | 0.291 | 0.0206 | 0.190 | 0.076 | — | 0.025 |
| | 24 | Log r. bass = 0.121 + 0.020 temp + 0.037 wdir | 37 | 0.131 | 0.0915 | 0.048 | --- | --- | 0.083 |

+ Logarithims are to the base 10.

* Temp = mean temperature (Nanticoke trap nets) or surface temperature (Centre Creek trap nets) of water column;
Secchi = secchi depth (transparency);
Wspd = maximum wind speed;
Wdir = wind direction at maximum wind speed;

**Independent variable explained < 0.01 of the $R^2$ value and was excluded from linear regression.

Table 3.2.1-36. Correlation of environmental variables with mean catch ($\log_{10} x + 1$) per lift of yellow perch, rock bass, and all fish in the East and West Plume (NTGS) trap nets, 1982-1983. Correlation coefficients are summarized by season with sample sizes (N) given in brackets.

| SPECIES GROUP | PLUME NET LOCATION | WATER TEMPERATURE* | | WIND SPEED | | WIND DIRECTION | | WAVE INDEX | | STATION | | SECCHI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | MEAN | OUTFALL | MEAN | MAX. | MOST FREQ. | AT MAX. WIND SPD. | MEAN | AT MAX. WIND SPD. | FLOW | POWER | |
| | | | | | | SPRING (N = 18) | | | | | | |
| Y. Perch | East | -0.748[b] | -0.773[c] | -0.083 | 0.185 | 0.142 | 0.229 | 0.009 | 0.241 | -0.327 | -0.360 | -0.369 |
| | West | -0.651[b] | -0.742[b] | -0.141 | 0.075 | 0.242 | 0.185 | 0.098 | 0.191 | -0.257 | -0.244 | -0.245 |
| R. Bass | East | -0.314 | -0.399 | 0.037 | 0.200 | 0.072 | 0.401 | 0.056 | 0.462[a] | -0.003 | -0.022 | -0.525[a] |
| | West | -0.270 | -0.015 | 0.435 | 0.515[a] | 0.097 | 0.257 | 0.253 | 0.388 | -0.114 | 0.153 | -0.504[a] |
| All Fish | East | -0.363 | -0.466[a] | 0.092 | 0.356 | 0.121 | 0.439 | 0.109 | 0.512[a] | -0.049 | -0.076 | -0.590[a] |
| | West | -0.645[a] | -0.582[a] | 0.219 | 0.437 | 0.383 | 0.504[a] | 0.392 | 0.383 | -0.293 | -0.232 | -0.518[a] |
| | | | | | | EARLY SUMMER (N = 25) | | | | | | |
| Y. Perch | East | -0.124 | -0.276 | -0.037 | 0.214 | -0.189 | -0.225 | -0.166 | -0.194 | 0.172 | -0.334 | 0.106 |
| | West | -0.410[a] | -0.576[a] | -0.125 | 0.033 | -0.110 | 0.100 | -0.150 | 0.115 | 0.519[a] | -0.211 | -0.324 |
| R. Bass | East | -0.198 | -0.219 | -0.401 | -0.346 | -0.015 | 0.016 | -0.158 | -0.042 | 0.275 | 0.058 | 0.269 |
| | West | -0.274 | -0.200 | -0.217 | 0.060 | -0.186 | 0.038 | -0.223 | 0.038 | 0.592[a] | 0.212 | -0.323 |
| All Fish | East | -0.239 | -0.343 | -0.304 | -0.178 | -0.160 | -0.138 | -0.257 | -0.170 | 0.415[a] | -0.026 | 0.222 |
| | West | -0.394 | -0.520[a] | -0.230 | -0.009 | -0.210 | 0.059 | -0.273 | 0.048 | 0.649[b] | -0.053 | -0.328 |
| | | | | | | LATE SUMMER (N = 22) | | | | | | |
| Y. Perch | East | -0.055 | -0.182 | 0.462[a] | 0.122 | 0.313 | 0.322 | 0.447[a] | 0.313 | 0.222 | -0.144 | -0.188 |
| | West | -0.326 | -0.379 | 0.487[a] | 0.104 | 0.060 | -0.204 | 0.191 | -0.166 | 0.146 | -0.386 | -0.066 |
| R. Bass | East | 0.576[a] | 0.699[b] | -0.321 | 0.086 | -0.233 | 0.132 | -0.314 | 0.127 | -0.494[a] | 0.607[a] | -0.468[a] |
| | West | -0.110 | -0.174 | 0.105 | 0.265 | -0.052 | -0.229 | -0.018 | -0.171 | 0.099 | -0.194 | -0.069 |
| All Fish | East | 0.567[a] | 0.618[a] | -0.052 | 0.251 | -0.158 | -0.062 | -0.148 | -0.020 | -0.404 | 0.459[a] | -0.571[a] |
| | West | 0.293 | 0.335 | 0.299 | 0.506[a] | -0.289 | -0.399 | -0.204 | -0.294 | -0.107 | 0.218 | -0.482[a] |
| | | | | | | FALL (N = 25) | | | | | | |
| Y. Perch | East | -0.503[a] | -0.567[a] | -0.151 | -0.113 | 0.026 | 0.084 | -0.044 | 0.008 | 0.147 | -0.297 | 0.272 |
| | West | -0.022 | 0.145 | 0.310 | 0.403[a] | -0.206 | -0.069 | -0.147 | 0.019 | -0.486[a] | 0.260 | -0.271 |
| R. Bass | East | -0.149 | -0.115 | 0.548[a] | 0.577[a] | 0.461[a] | 0.283 | 0.525[a] | 0.407[a] | -0.675[a] | -0.107 | -0.486[a] |
| | West | -0.032 | 0.113 | 0.603[b] | 0.712[a] | 0.253 | 0.238 | 0.360 | 0.376[a] | -0.541[a] | -0.123 | -0.509[a] |
| All Fish | East | -0.141 | 0.144 | 0.382[a] | 0.459[a] | 0.317 | 0.318 | 0.318 | 0.392[a] | -0.660[b] | -0.050 | -0.254 |
| | West | 0.325 | 0.487[a] | 0.527[a] | 0.546[a] | -0.016 | -0.070 | 0.102 | 0.072 | -0.660[c] | 0.217 | -0.410[a] |
| | | | | | | SEASONS COMBINED (N = 90) | | | | | | |
| Y. Perch | East | -0.143 | -0.146 | 0.018 | 0.056 | -0.002 | 0.038 | -0.016 | 0.036 | 0.054 | -0.133 | -0.070 |
| | West | -0.504[c] | -0.505[c] | 0.091 | 0.202[a] | -0.077 | -0.047 | -0.076 | -0.003 | 0.095 | -0.189 | -0.217[a] |
| R. Bass | East | -0.527[c] | -0.417[c] | 0.108 | 0.267[b] | 0.004 | 0.116 | 0.023 | 0.185 | -0.008 | -0.047 | -0.351[b] |
| | West | -0.587[c] | -0.530[c] | 0.262[a] | 0.407[c] | -0.033 | 0.014 | 0.043 | 0.106 | 0.170[c] | 0.166 | [illegible] |
| All Fish | East | -0.317[b] | -0.222[a] | 0.107 | 0.269[c] | -0.049 | 0.085 | -0.027 | 0.152 | -0.036 | 0.043 | -0.382[b] |
| | West | -0.359[b] | -0.278[a] | 0.228[a] | 0.378 | -0.089 | -0.033 | -0.029 | 0.058 | 0.001 | -0.026 | -0.416[c] |

* mean = mean temperature of water column at trapnet location; outfall = mean temperature of heated effluent water discharge from the Nanticoke Thermal Generating Station

a = significant at P = 0.05; b = significant at P = 0.001; c = significant at P = 0.0001

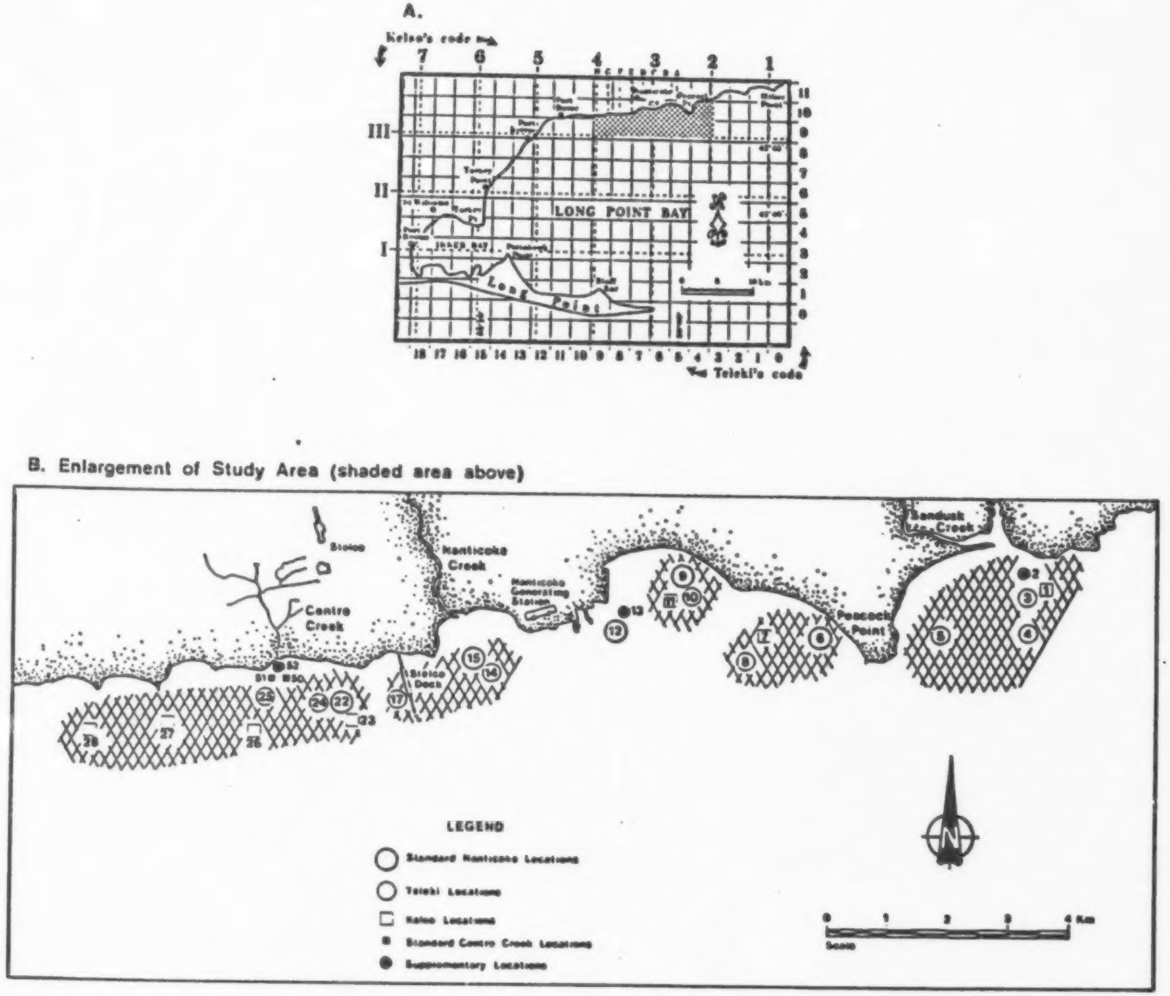
A.
Kelso's code
7
6
5
4
3
2
1
III
II
I
LONG POINT BAY
Long Point
Teleki's code
B. Enlargement of Study Area (shaded area above)
Stelco
Nanticoke Creek
Nanticoke Generating Station
Centre Creek
Stelco Dock
Peacock Point
Sanduck Creek
LEGEND
Standard Nanticoke Locations
Teleki Locations
Kelso Locations
Standard Centre Creek Locations
Supplementary Locations
0
1
2
3
4 Km
Scale

Figure 3.2.1-1. Long Point Bay (A), showing grid systems of Kelso (1971-1972) and Teleki (1973-1983). Trapnet locations sampled in 1971-1983 are shown in enlargement B. Shaded areas in B indicate trapnet sites in 1971-1974 that were pooled to correspond with standard locations sampled in 1975-1983. From west to east, the shaded areas represent the following: West Brown's Pt., East Brown's Pt., Oneida, Peacock Pt., and Selkirk (discontinued as a standard location in 1981).

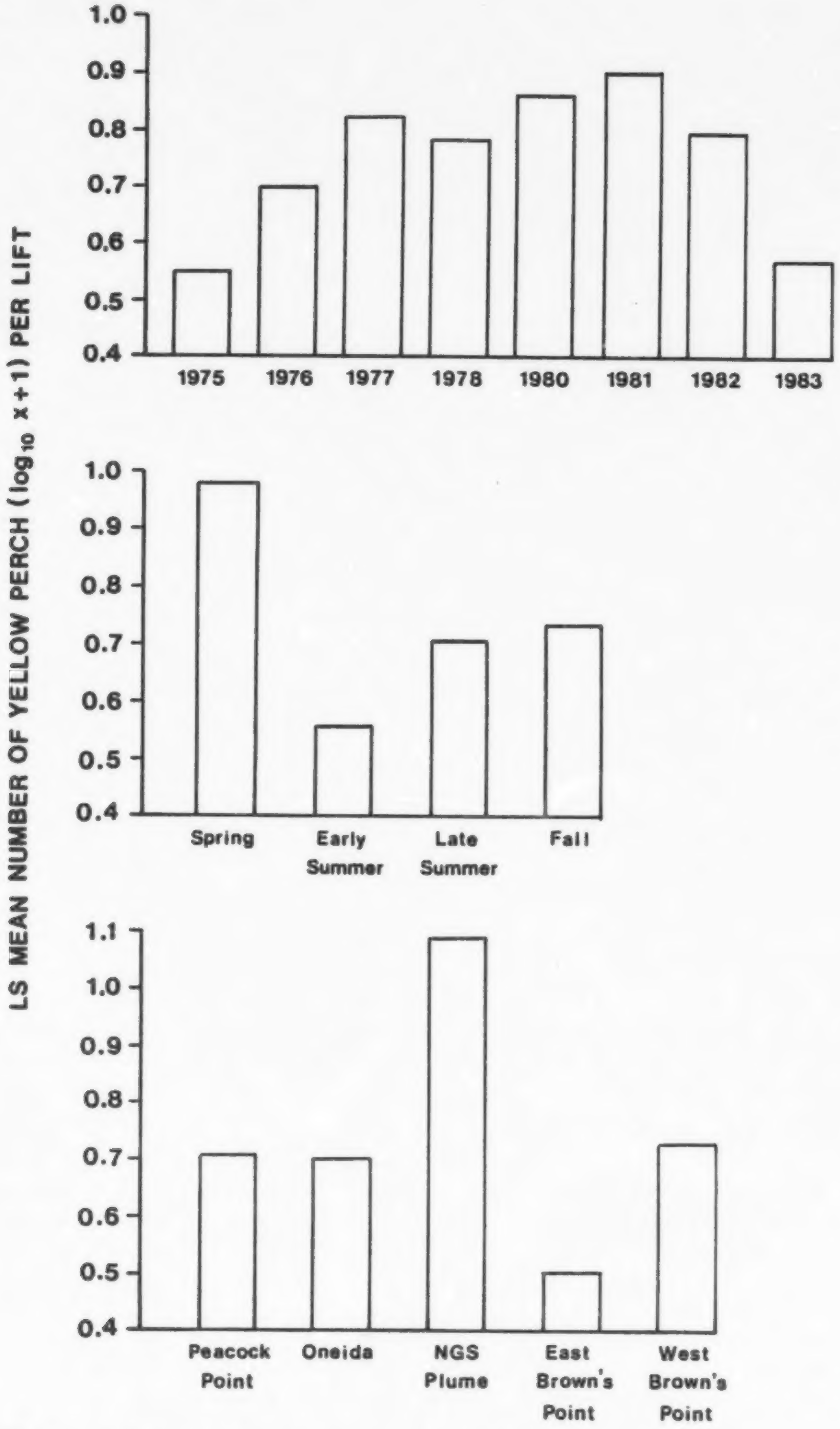

Figure 3.2.1-2. Least squares mean (LS Mean) number of yellow perch caught per lift in standard trapnets at Nanticoke by year (1975-1983), by season (April - October), and by location.

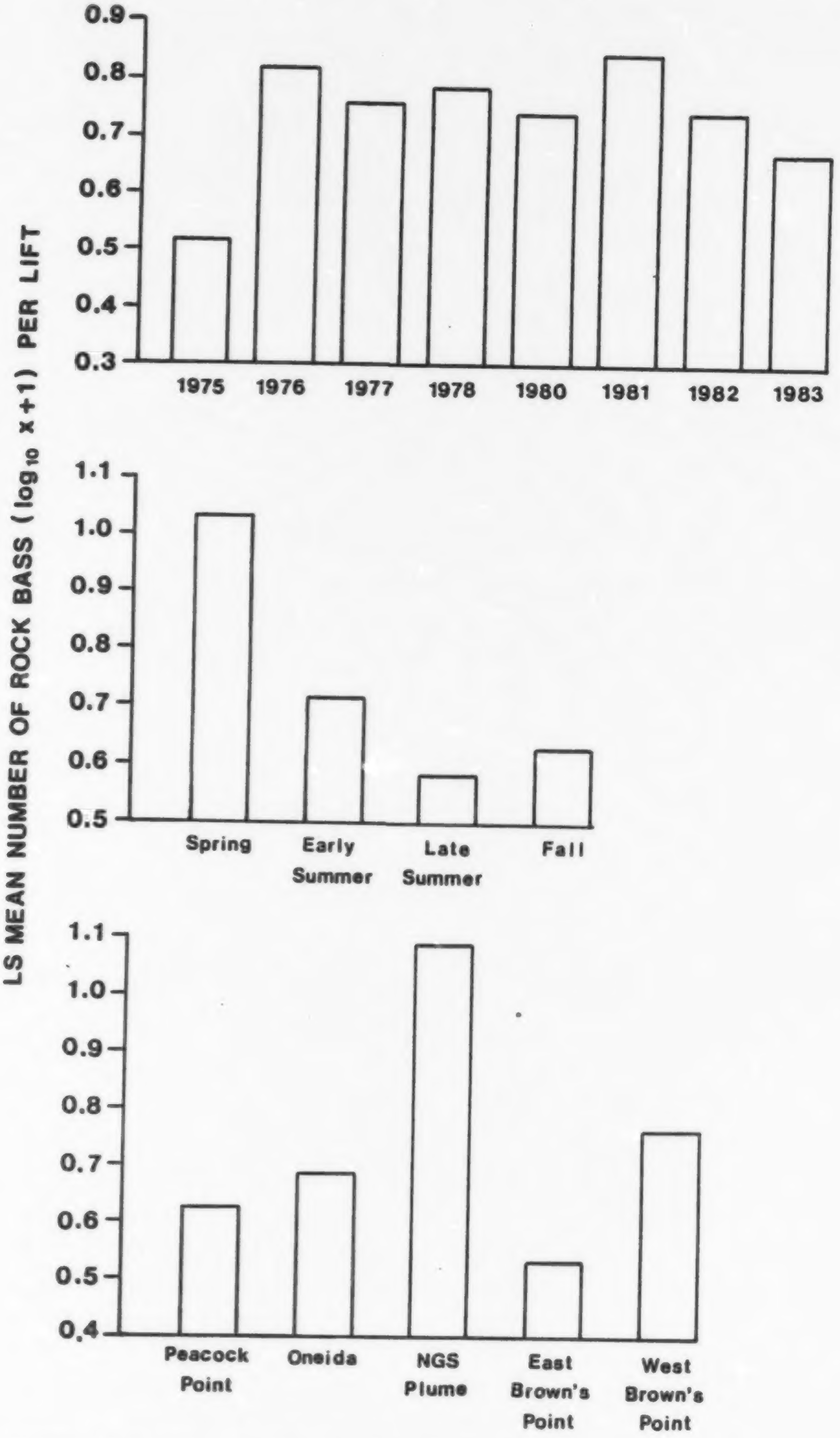

Figure 3.2.1-3. Least squares mean (LS Mean) number of rock bass caught per lift in standard trapnets at Nanticoke by year (1975-1983), by season (April - October), and by location.

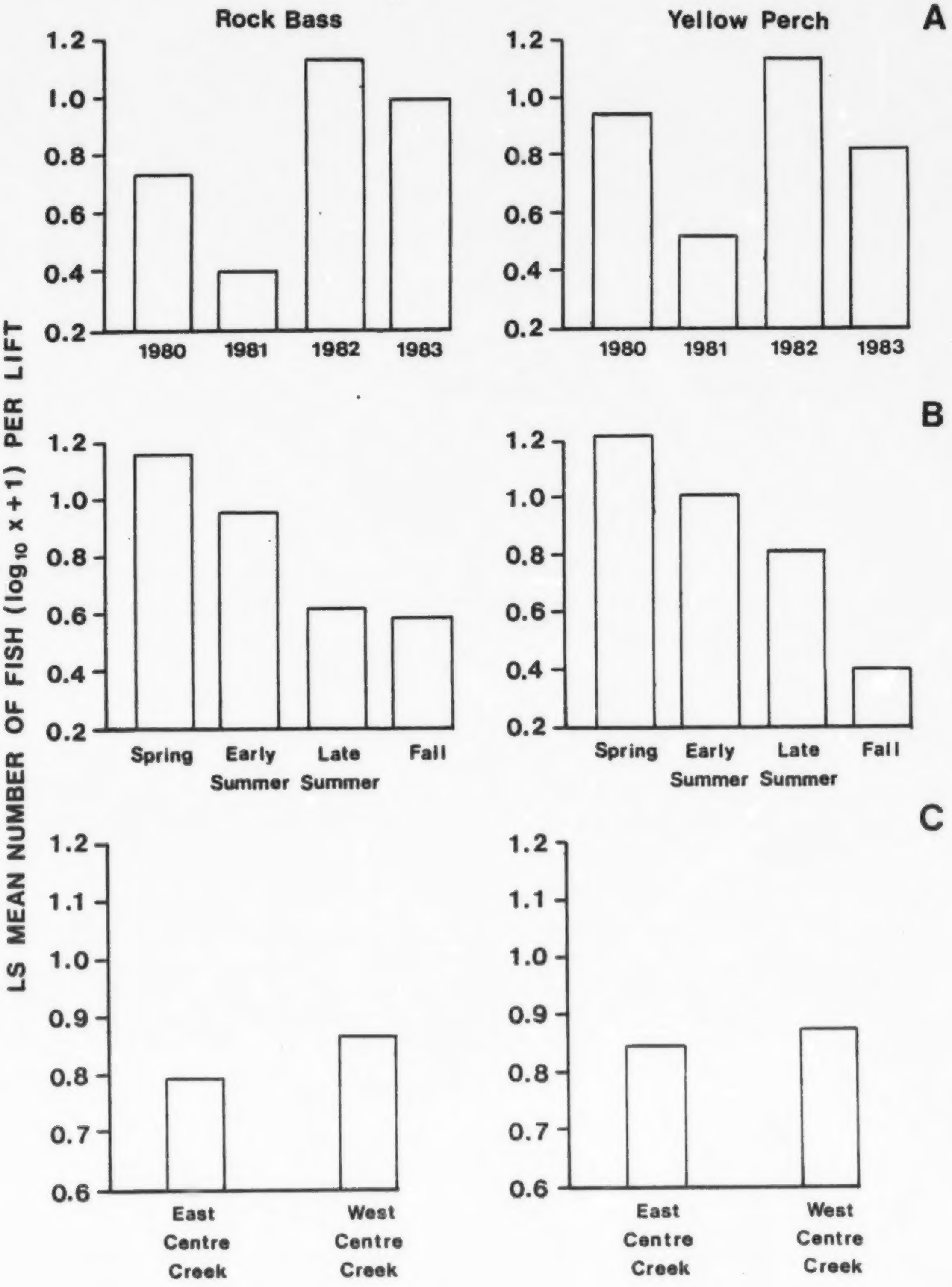

Figure 3.2.1-4. Least squares mean (LS Mean) number of rock bass and yellow perch caught per lift in standard trapnets at Centre Creek by year (A), by season (B), and by location (C).

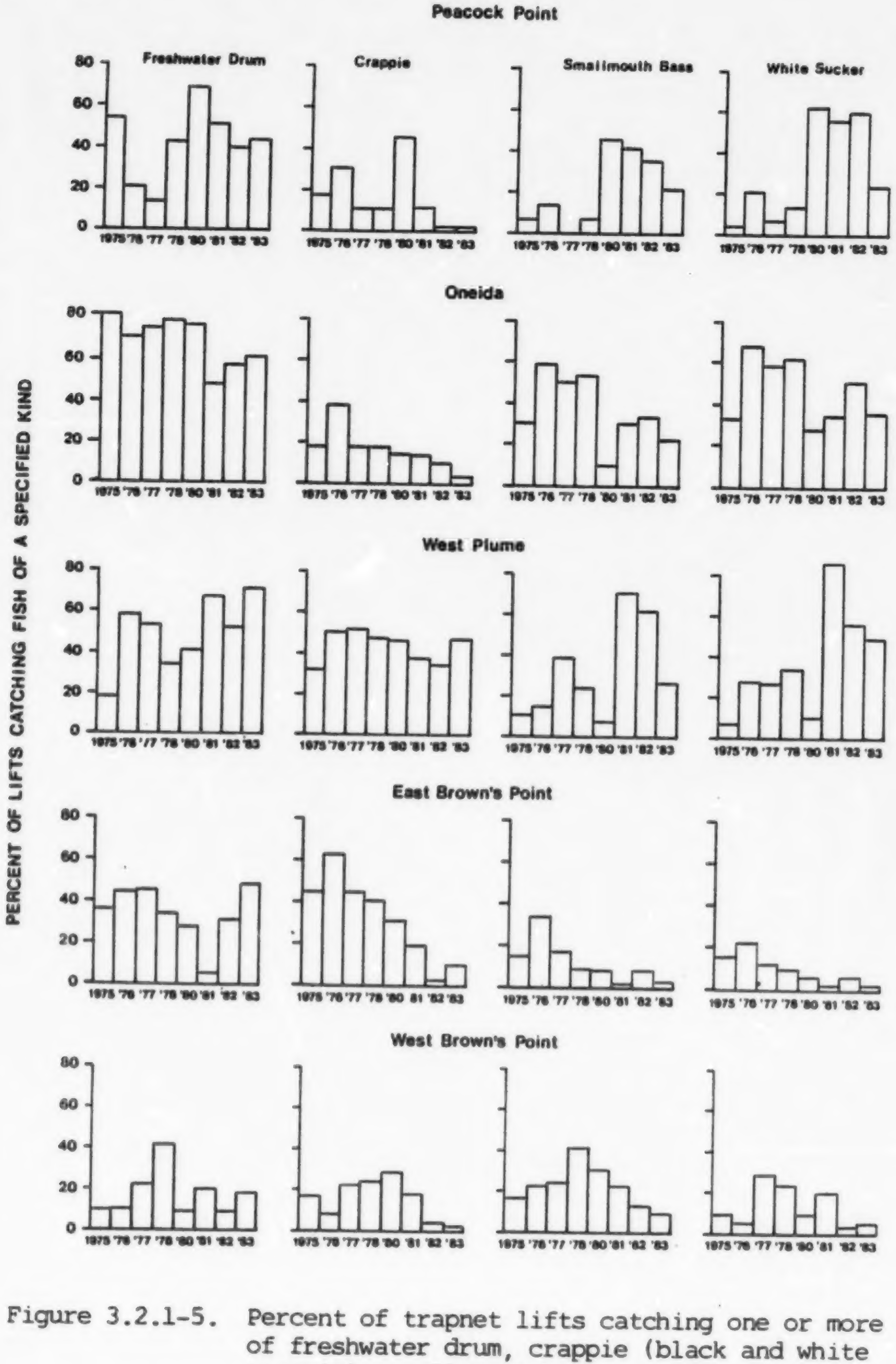

Figure 3.2.1-5. Percent of trapnet lifts catching one or more of freshwater drum, crappie (black and white crappie), smallmouth bass, and white sucker at Nanticoke by year and location.

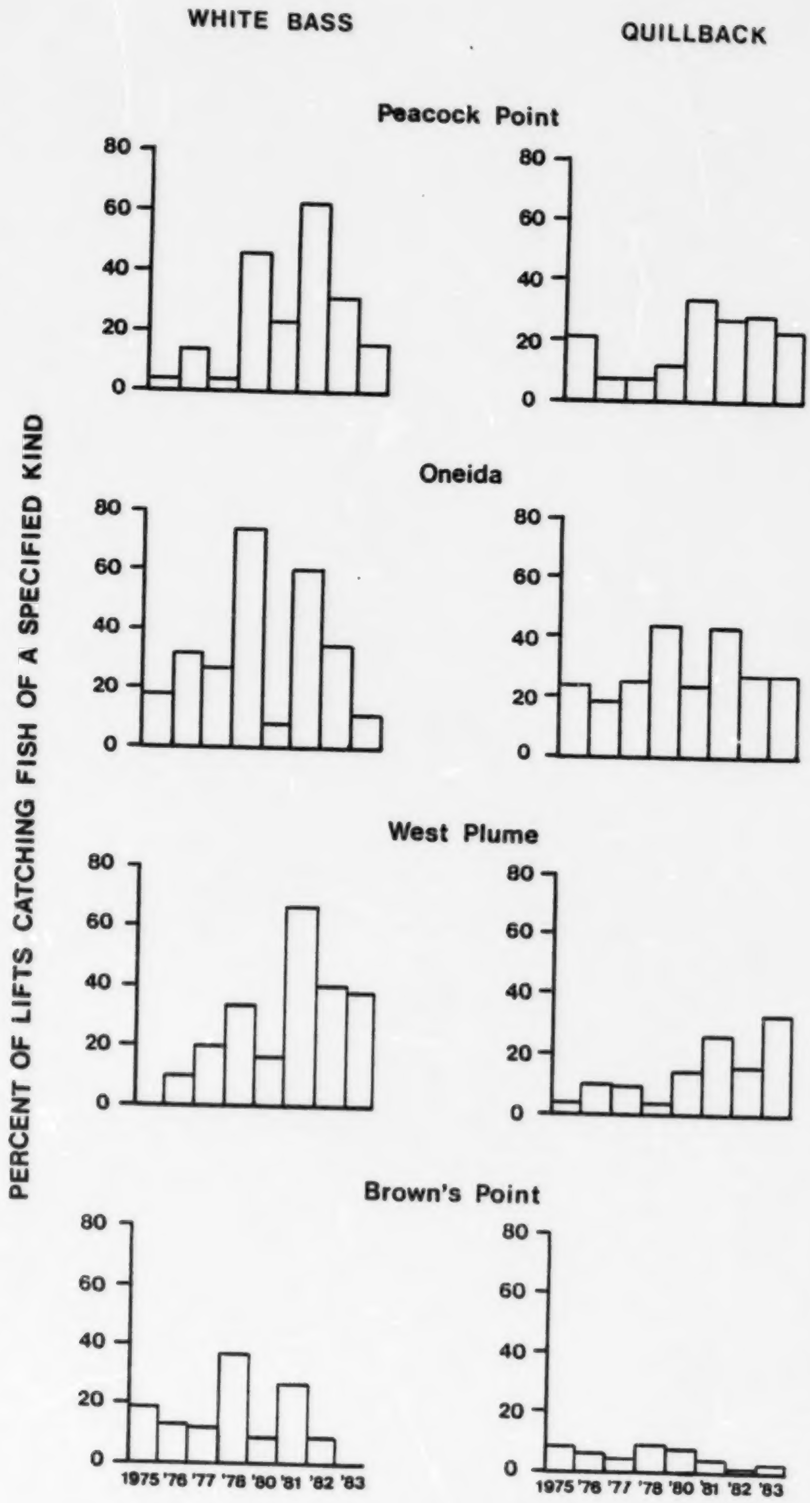

Figure 3.2.1-6. Percent of trapnet lifts catching one or more of white bass and quillback at Nanticoke by year and location. (Brown's Point = East and West Brown's Points).

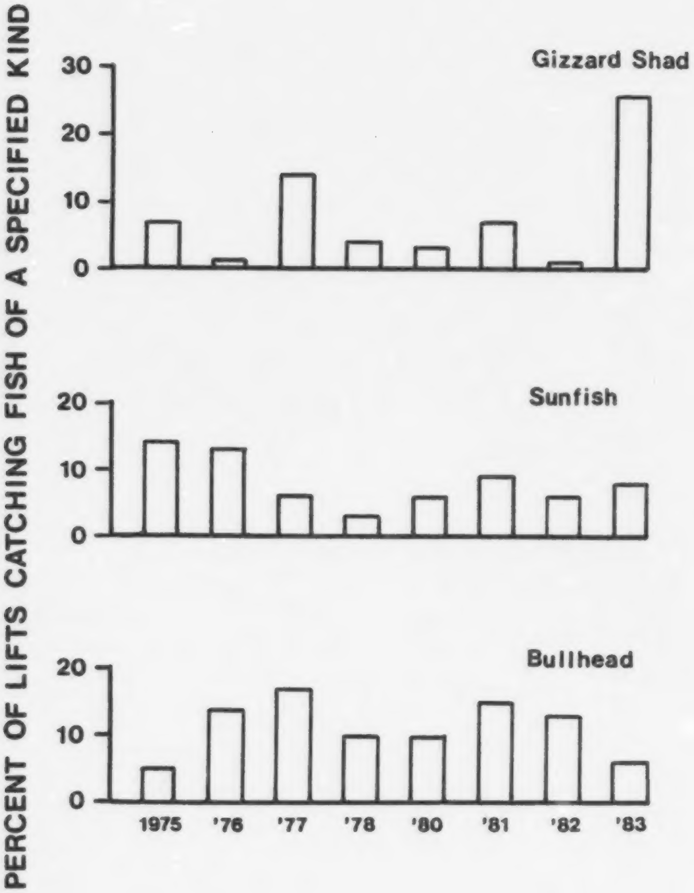

Figure 3.2.1-7. Percent of trapnet lifts catching one or more of gizzard shad, sunfish (bluegill and pumpkinseed), and bullhead (brown and yellow bullhead) at Nanticoke (pooled standard locations) by year.

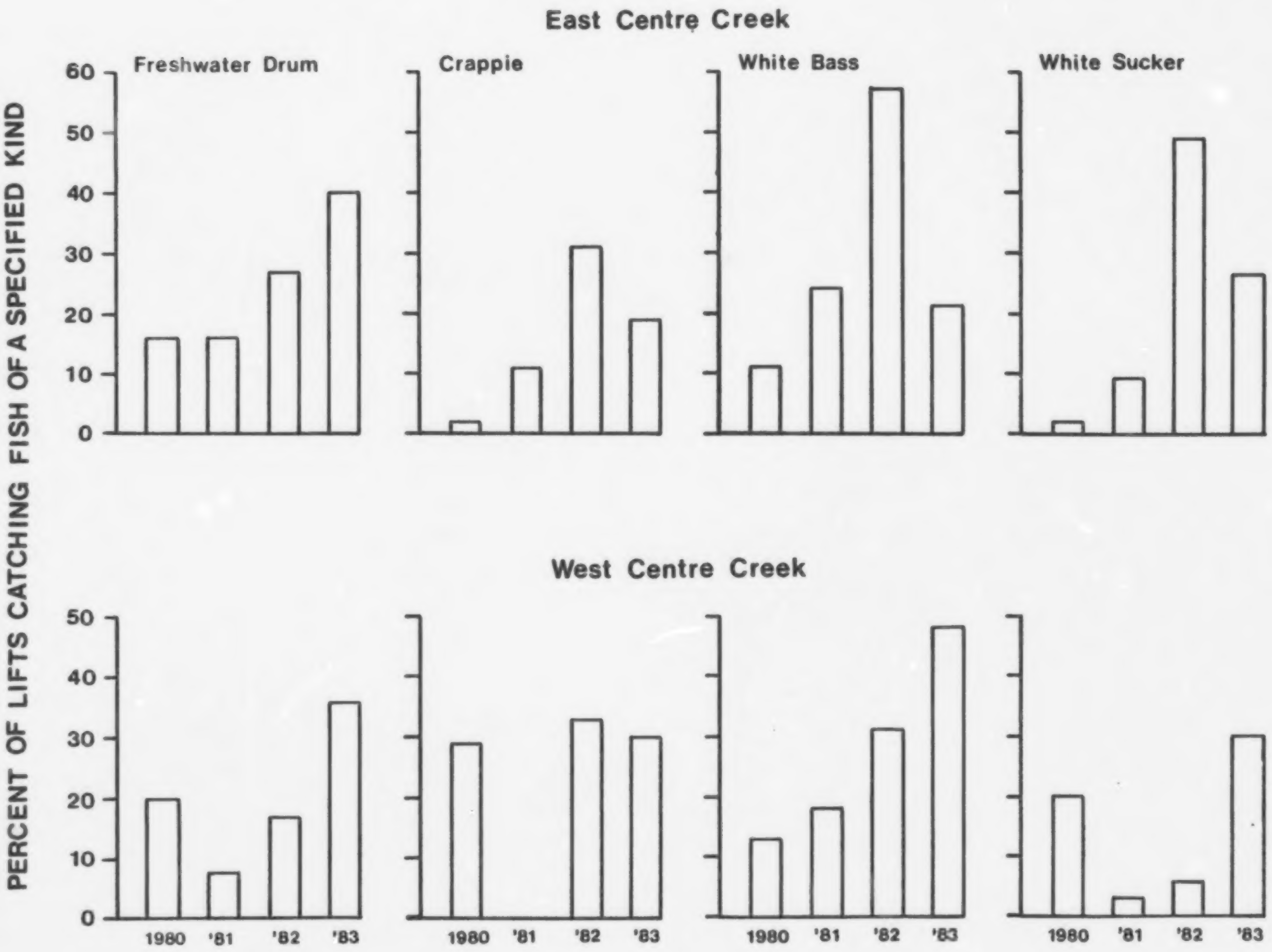

Figure 3.2.1-8. Percent of trapnet lifts catching one or more of freshwater drum, crappie (black and white crappie), white bass, and white sucker at Centre Creek by location and year.

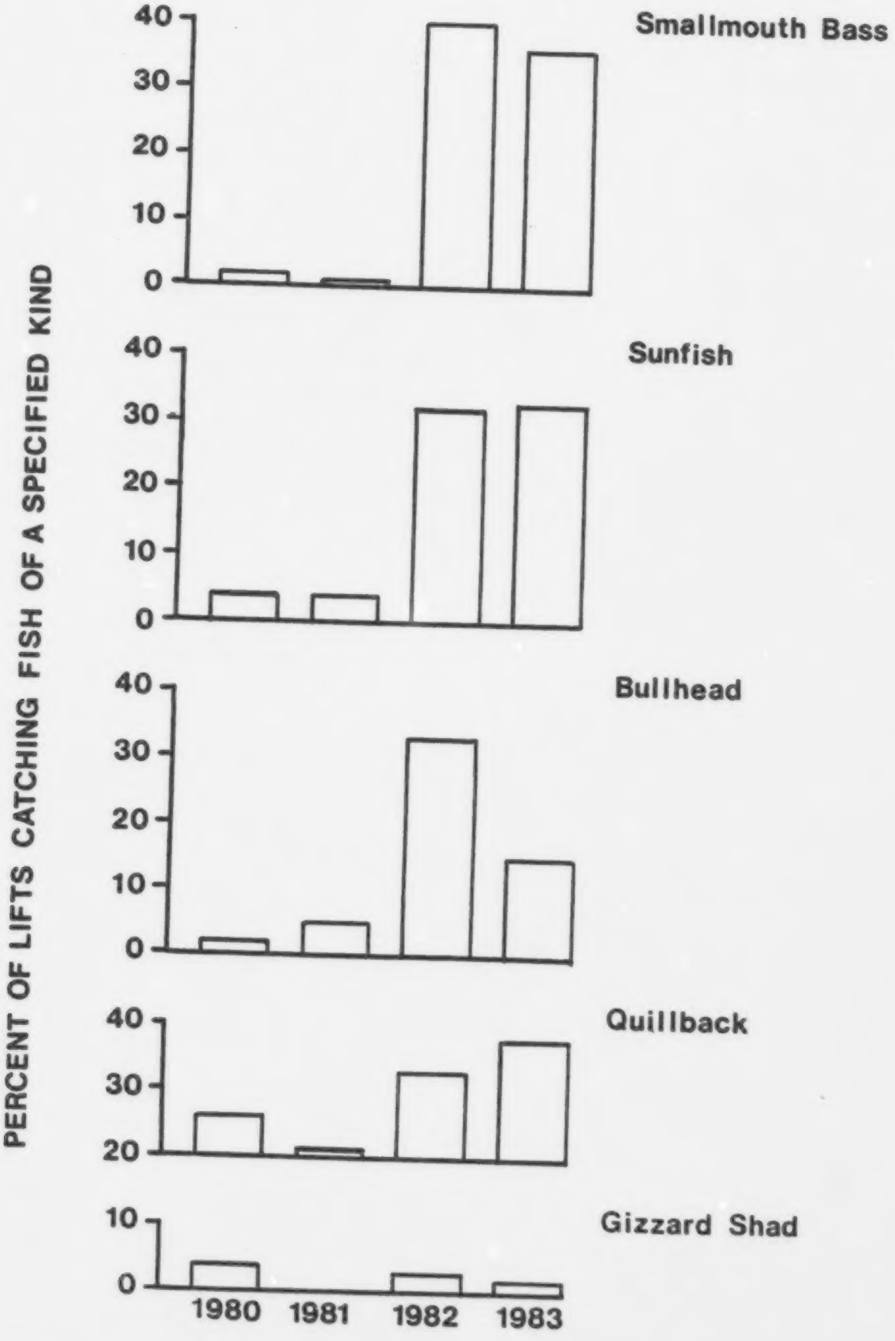

Figure 3.2.1-9. Percent of trapnet lifts catching one or more of smallmouth bass, sunfish (bluegill and pumpkinseed), bullhead (brown and yellow bullhead), quillback, and gizzard shad at Centre Creek (pooled standard locations).

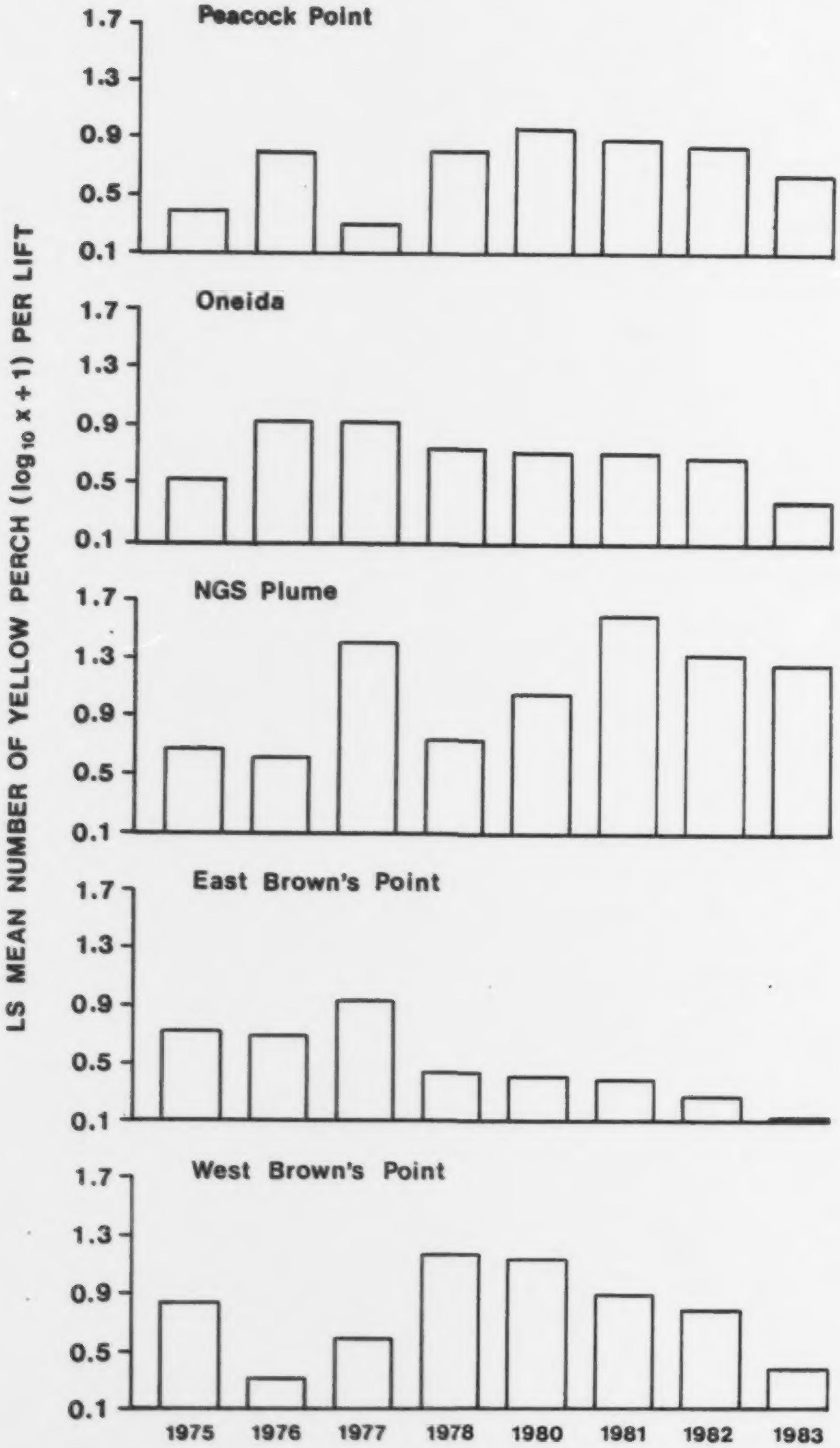

Figure 3.2.1-10. Least squares mean (LS Mean) number of yellow perch caught per lift in standard trapnets at Nanticoke by location and year (1975-1983).

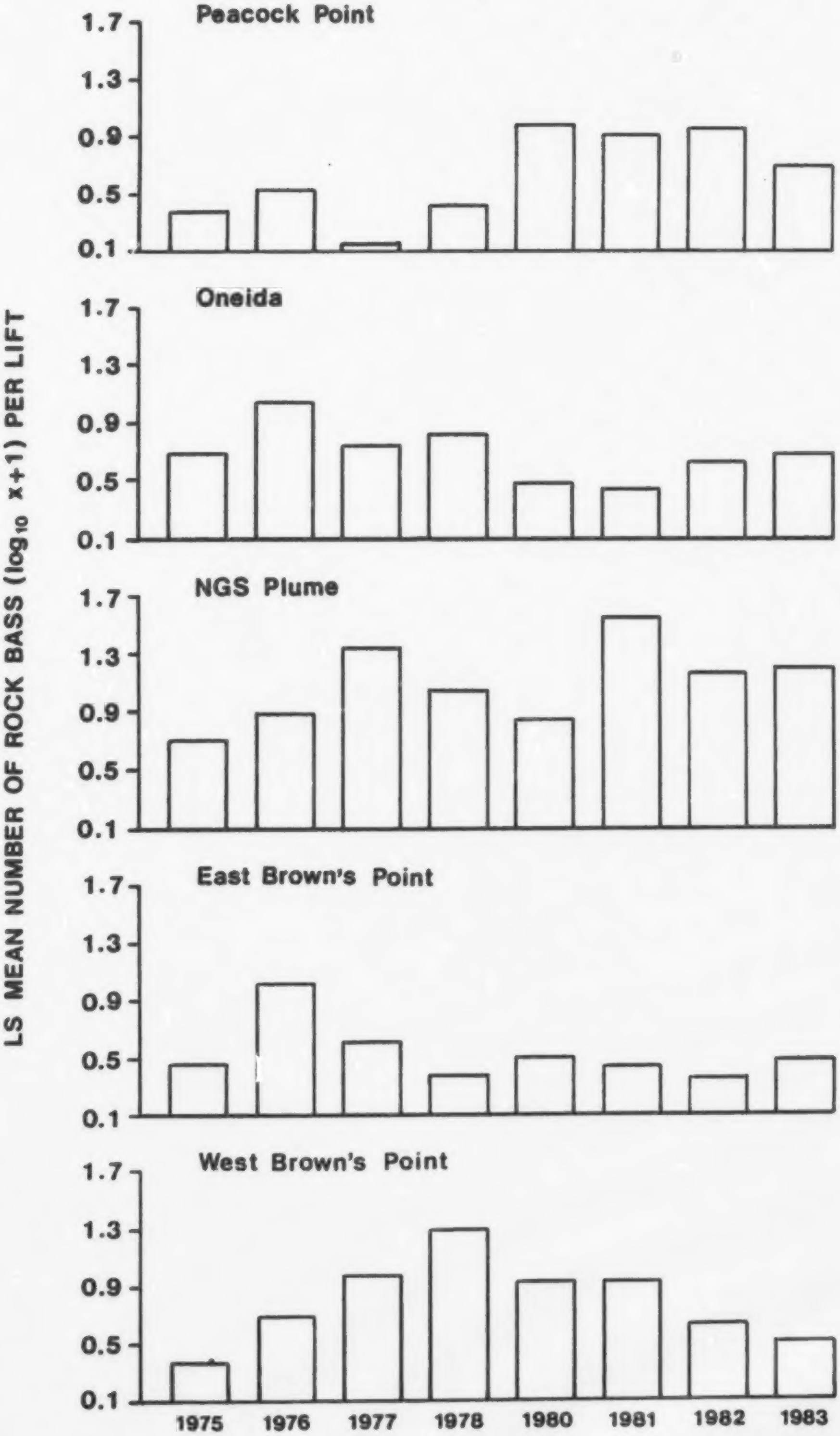

Figure 3.2.1-11. Least squares mean (LS Mean) number of rock bass caught per lift in standard trapnets at Nanticoke by location and year (1975-1983).

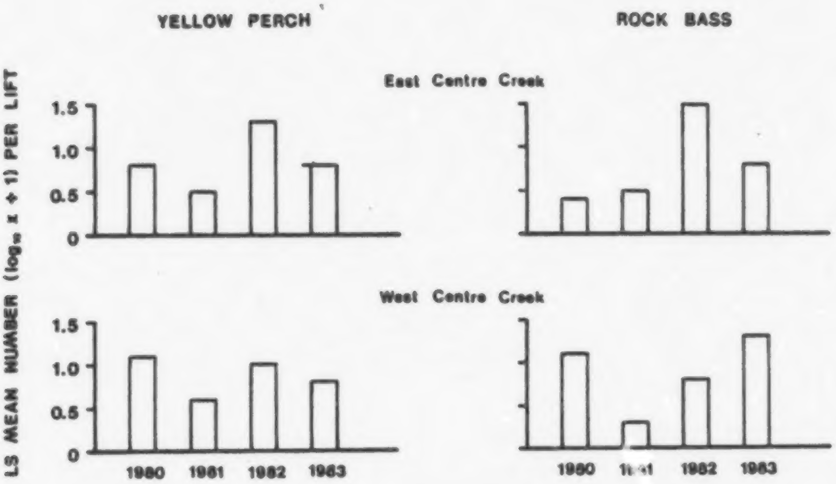

Figure 3.2.1-12. Least squares mean (LS Mean) number of yellow perch and rock bass caught in Centre Creek trap nets by year and location.

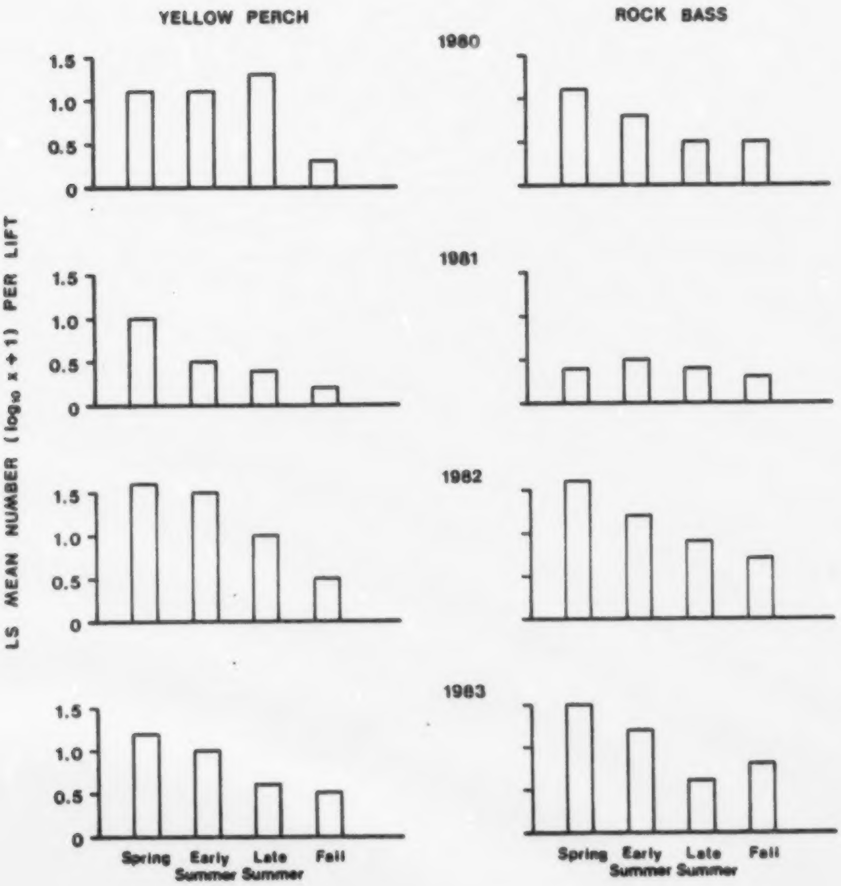

Figure 3.2.1-13. Least squares mean (LS Mean) number of yellow perch and rock bass caught in Centre Creek trap nets by year and season.

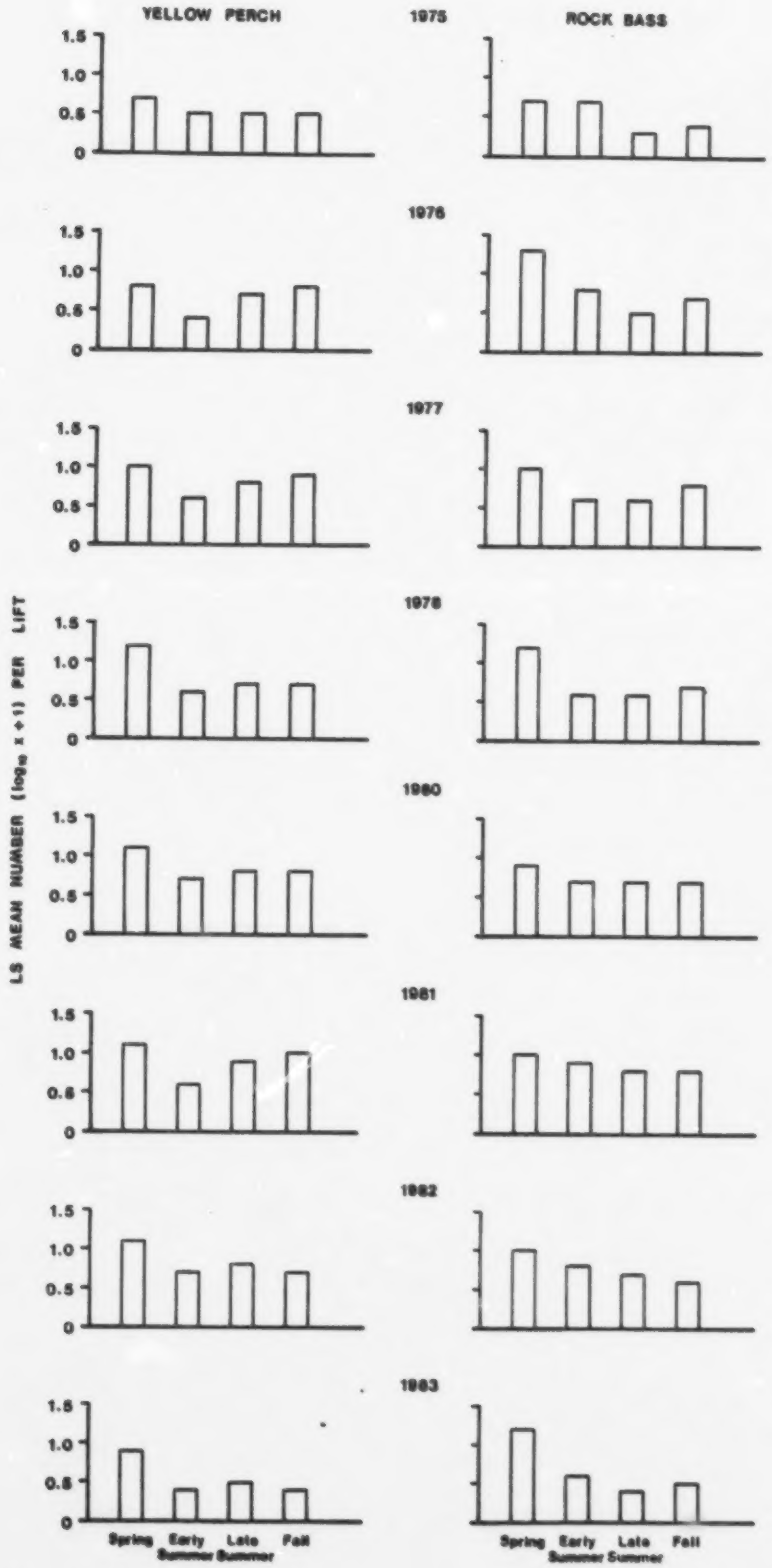

Figure 3.2.1-14. Least squares mean (LS Mean) number of yellow perch and rock bass caught in Nanticoke trap nets by year and season.

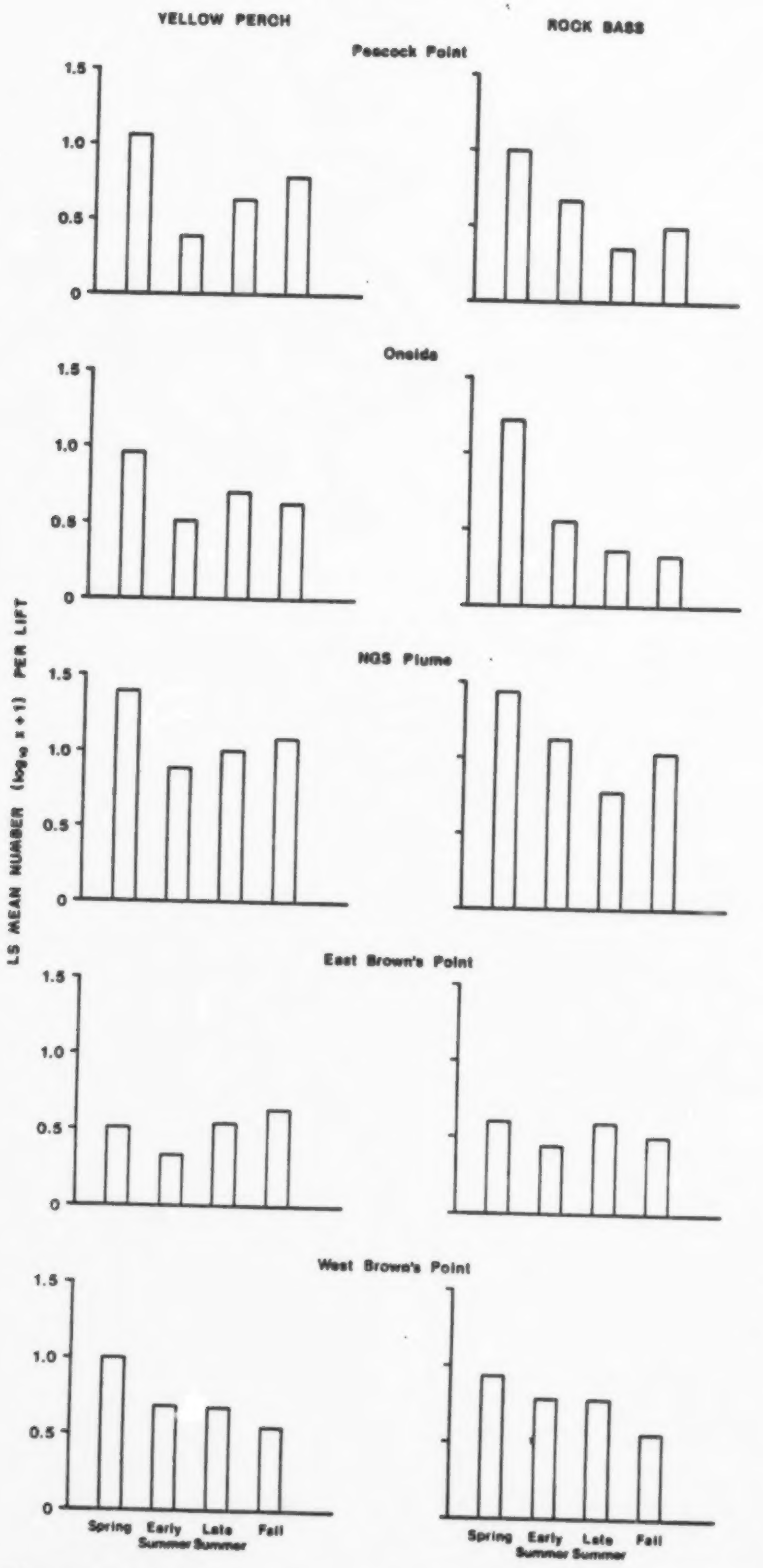

Figure 3.2.1-15. Least squares mean (LS Mean) number of yellow perch and rock bass caught in Nanticoke trap nets by location and season, 1975-1983.

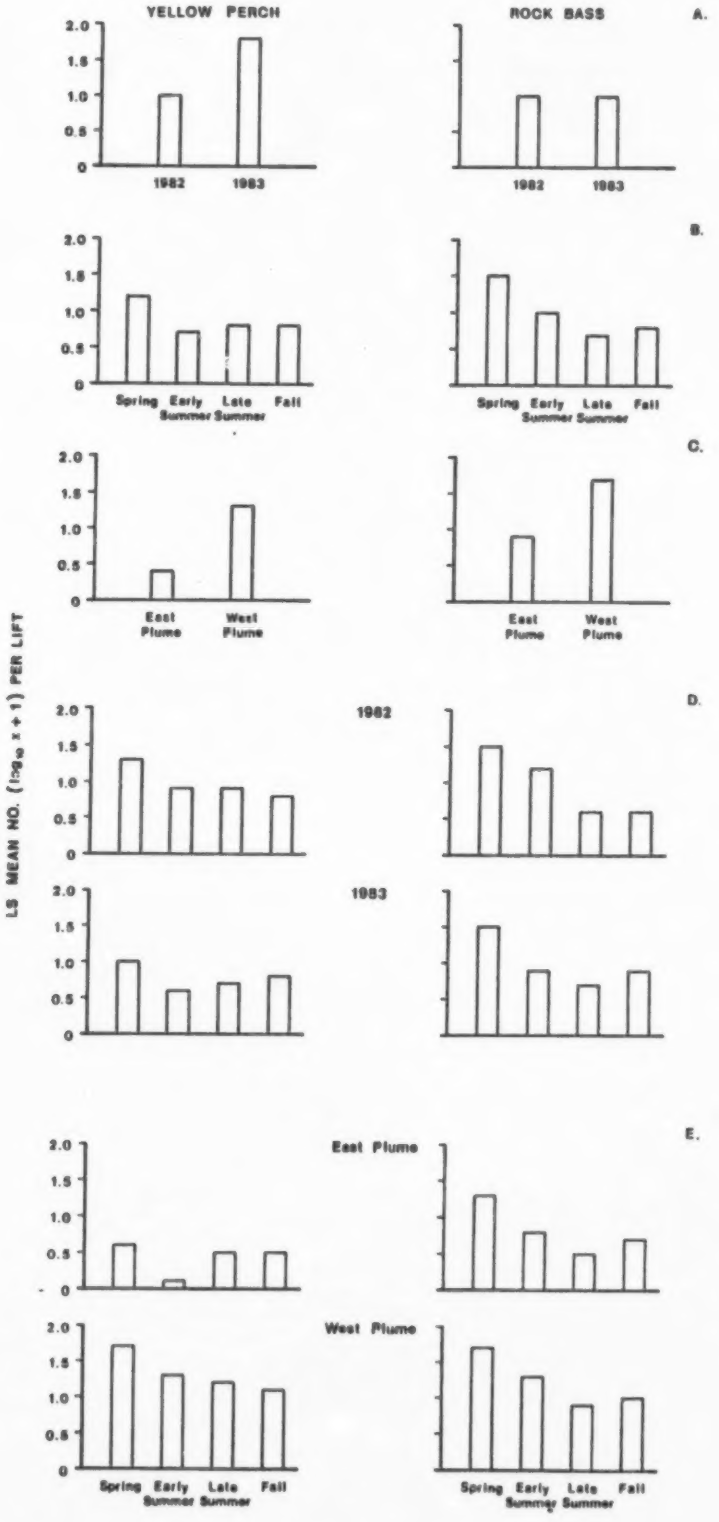

Figure 3.2.1-16. Least squares mean (LS Mean) number of yellow perch and rock bass caught in the East and West plume trap nets (A) by year, (B) by season, (C) by location, (D) by year and season, (E) by location and season.

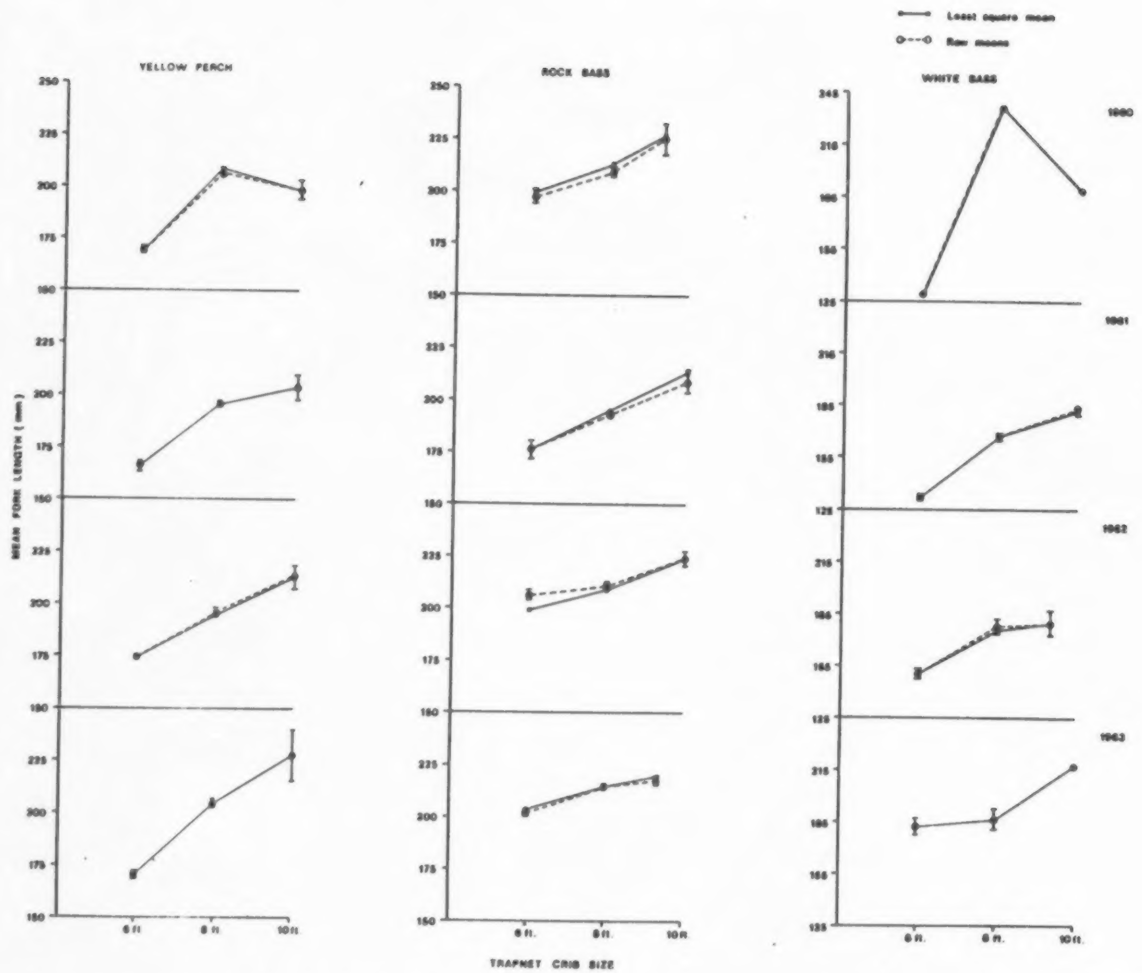

Figure 3.2.1-17. Arithmetic (raw) and least squares mean fork length of yellow perch, rock bass, and white bass captured in 6-ft trap nets at Centre Creek and 8- and 10-ft trap nets at Nanticoke by year (seasons combined).

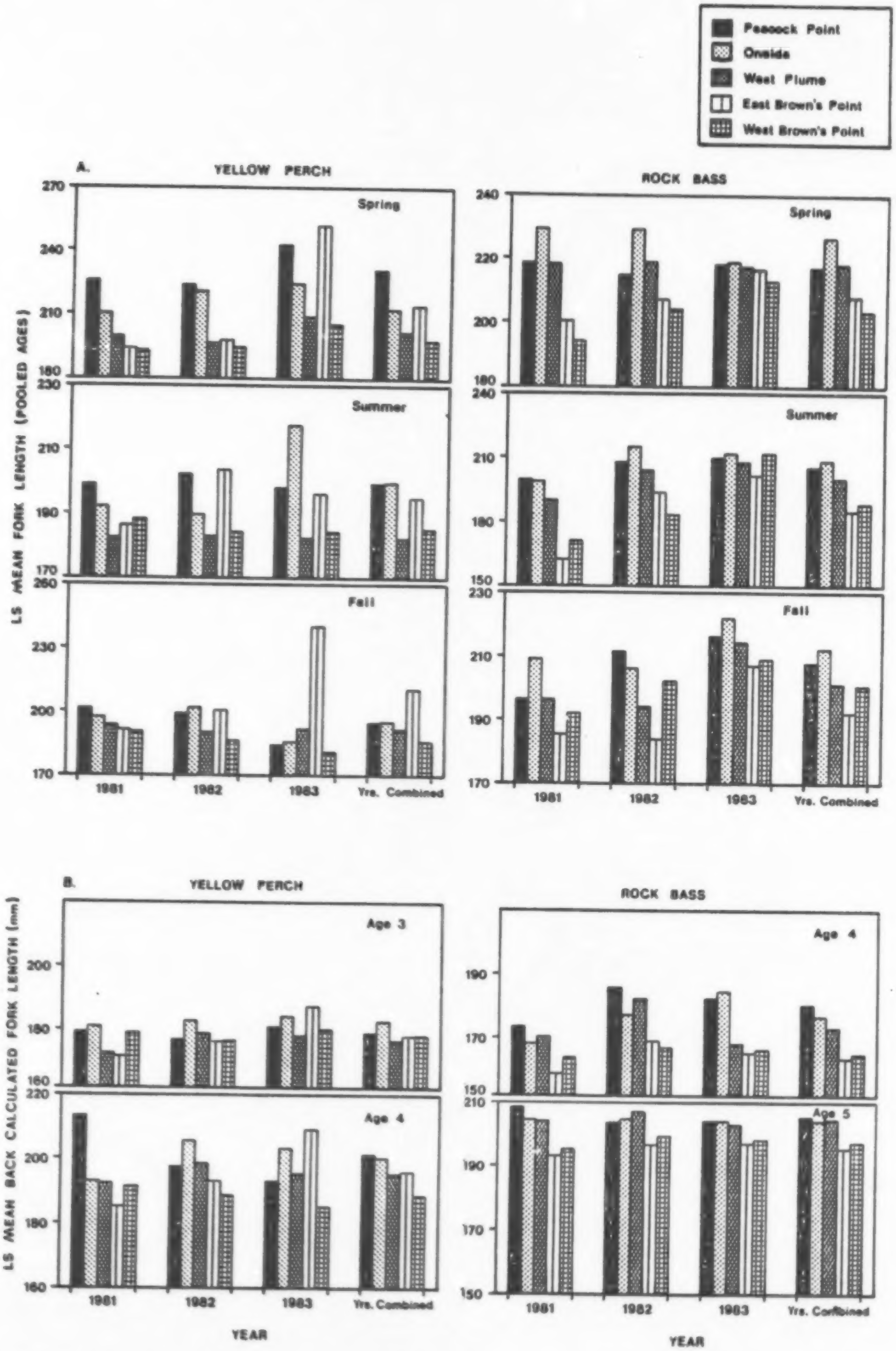

Figure 3.2.1-18. Comparisons of (A) seasonal least squares mean fork length (ages pooled) and (B) backcalculated fork lengths-at-age of yellow perch and rock bass across the five standard Nanticoke trap nets, 1981-1983.

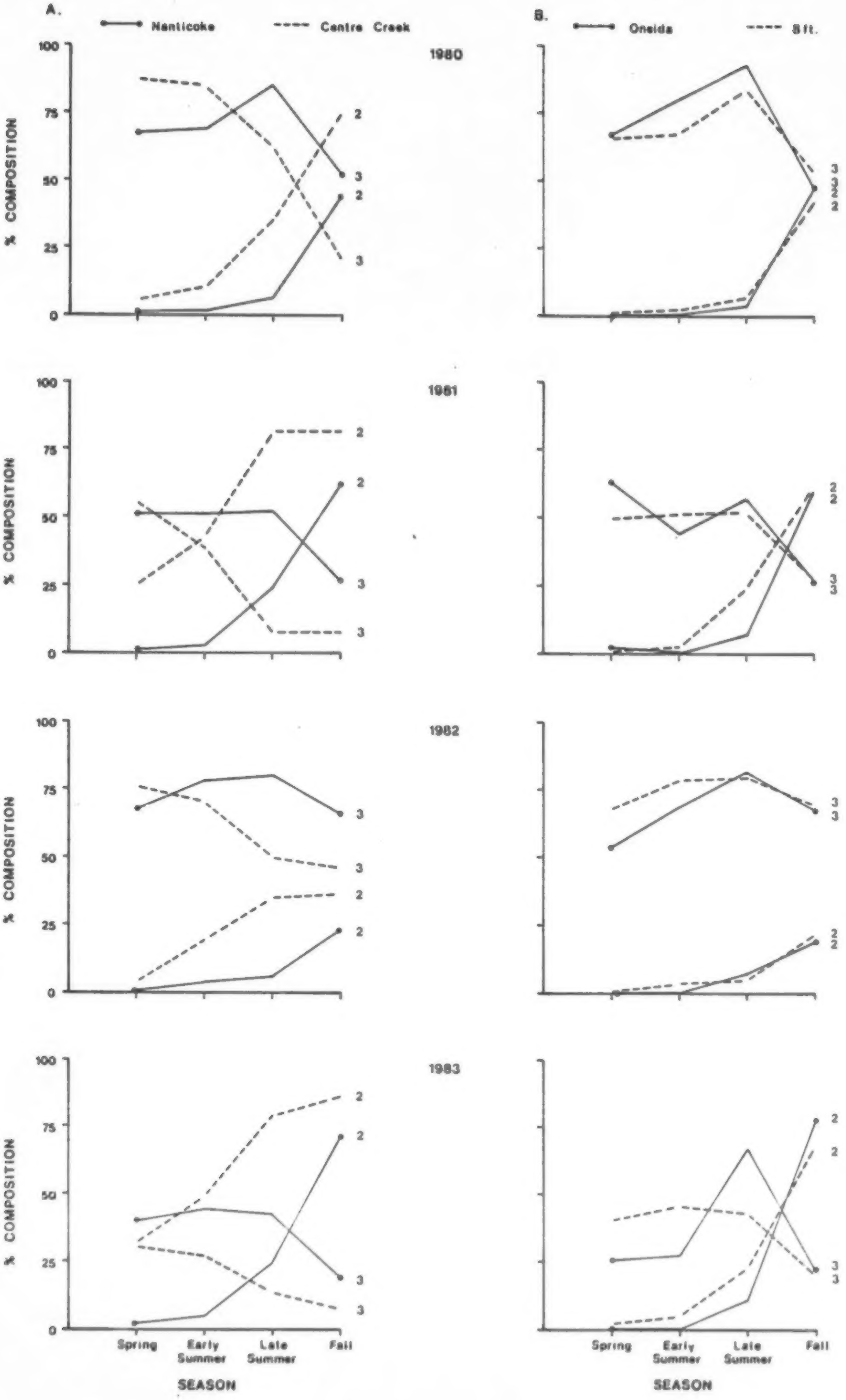

Figure 3.2.1-19. Seasonal (1980-1983) composition (%) of age 2 and age 3 yellow perch comparing:
A. Nanticoke (8- and 10-ft nets pooled) and Cèntre Creek (6-ft nets pooled) trapnet catches,
B. 10-ft (Oneida) and pooled 8-ft trapnet catches.

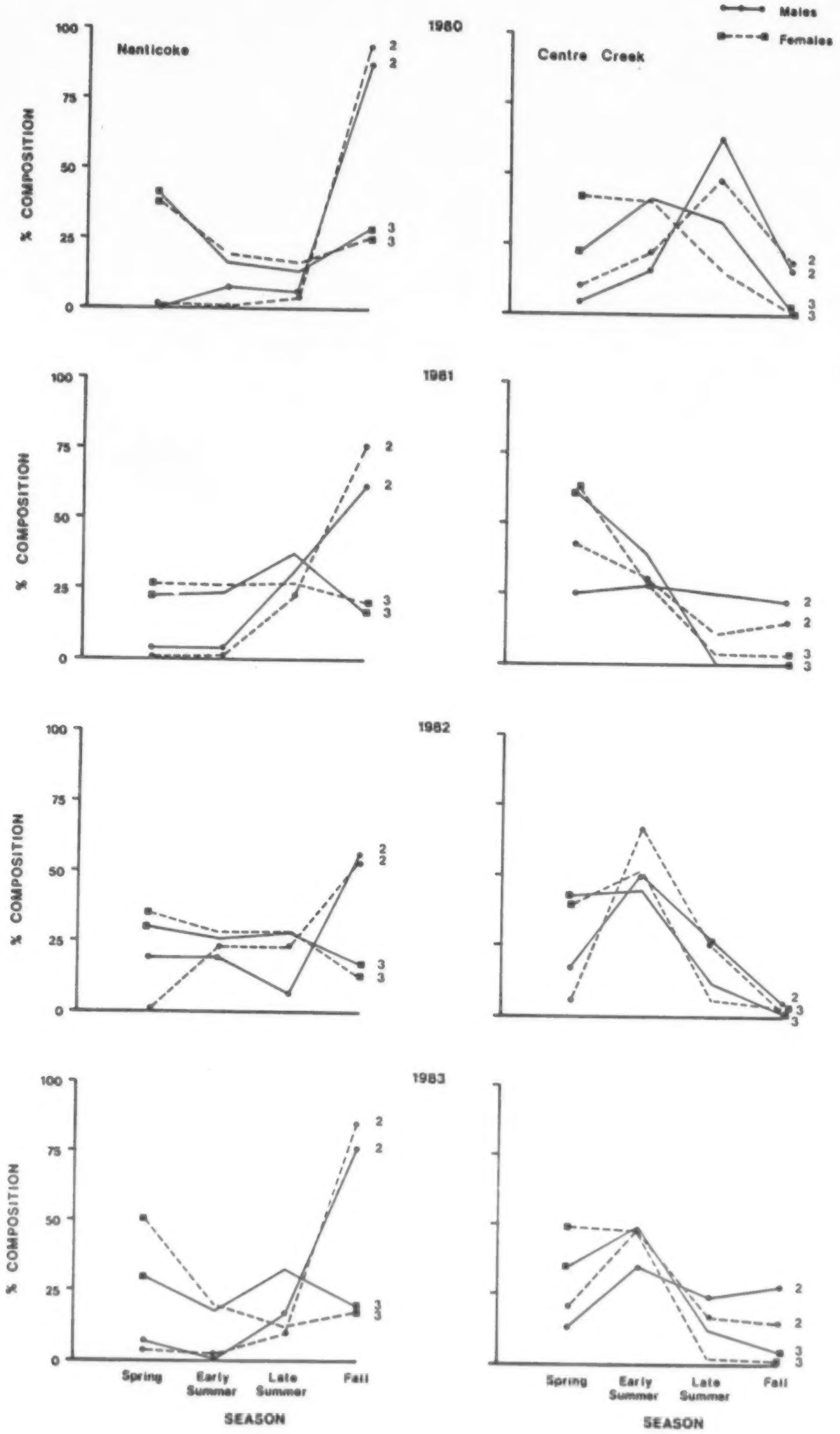

Figure 3.2.1-20. Seasonal composition (%) of age 2 and age 3 male and female yellow perch in Nanticoke (8- and 10-ft nets pooled) and Centre Creek (6-ft nets pooled) trapnet catches, Long Point Bay, Lake Erie (1980-1983).

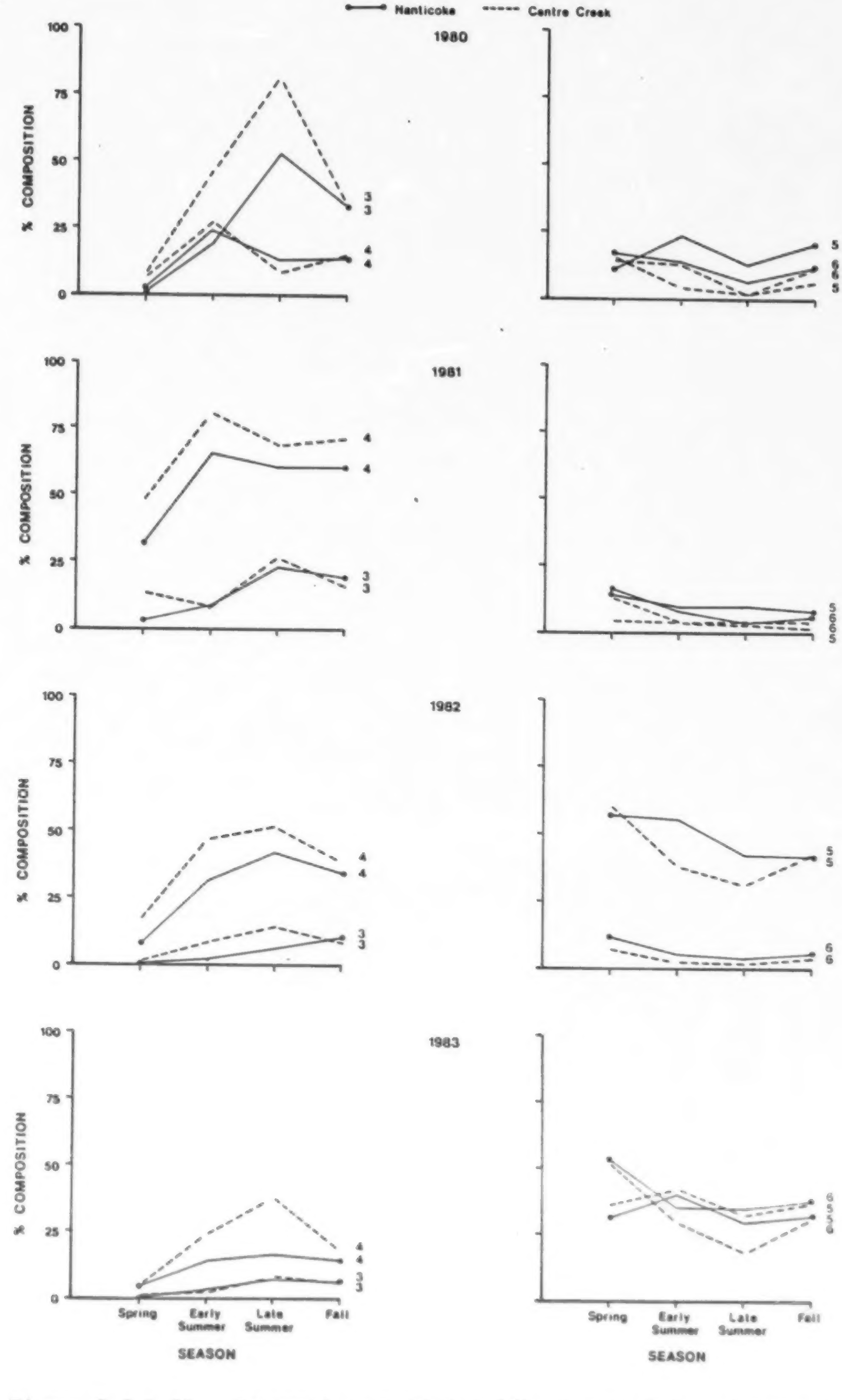

Figure 3.2.1-21. Seasonal composition (%) of ages 3-6 rock bass in Nanticoke (8- and 10-ft nets pooled) and Centre Creek (6-ft nets pooled) trapnet catches, Long Point Bay, Lake Erie (1980-1983).

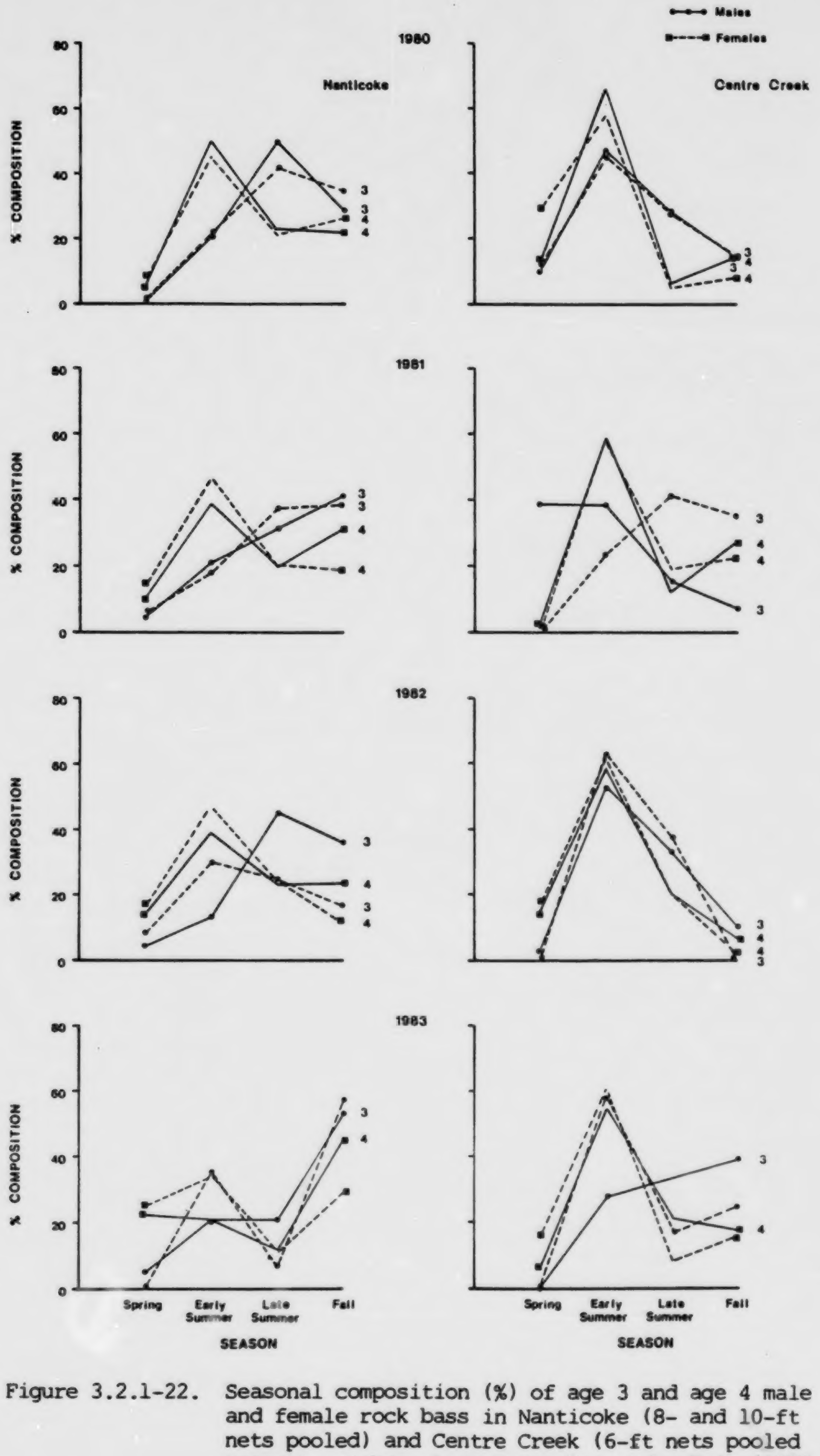

Figure 3.2.1-22. Seasonal composition (%) of age 3 and age 4 male and female rock bass in Nanticoke (8- and 10-ft nets pooled) and Centre Creek (6-ft nets pooled trapnet catches, Long Point Bay, Lake Erie (1980-1983).

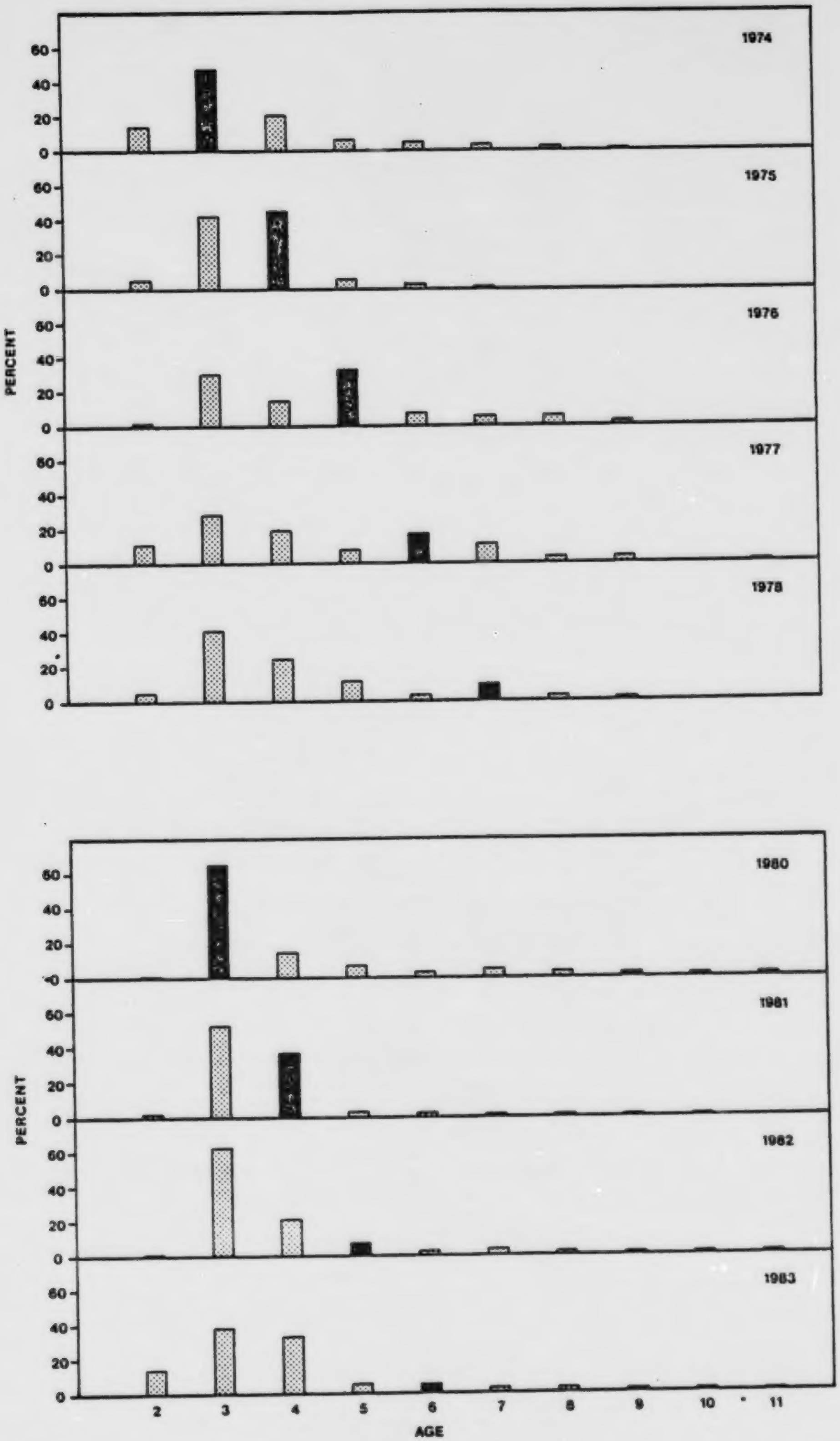

Figure 3.2.1-23. Spring age composition(%) of yellow perch in Nanticoke (8- and 10-ft nets pooled) trapnet catches, Long Point Bay, Lake Erie (1974-1983). Values for 1974-1978 are estimated from age-length keys. Shaded bars highlight strong year classes.

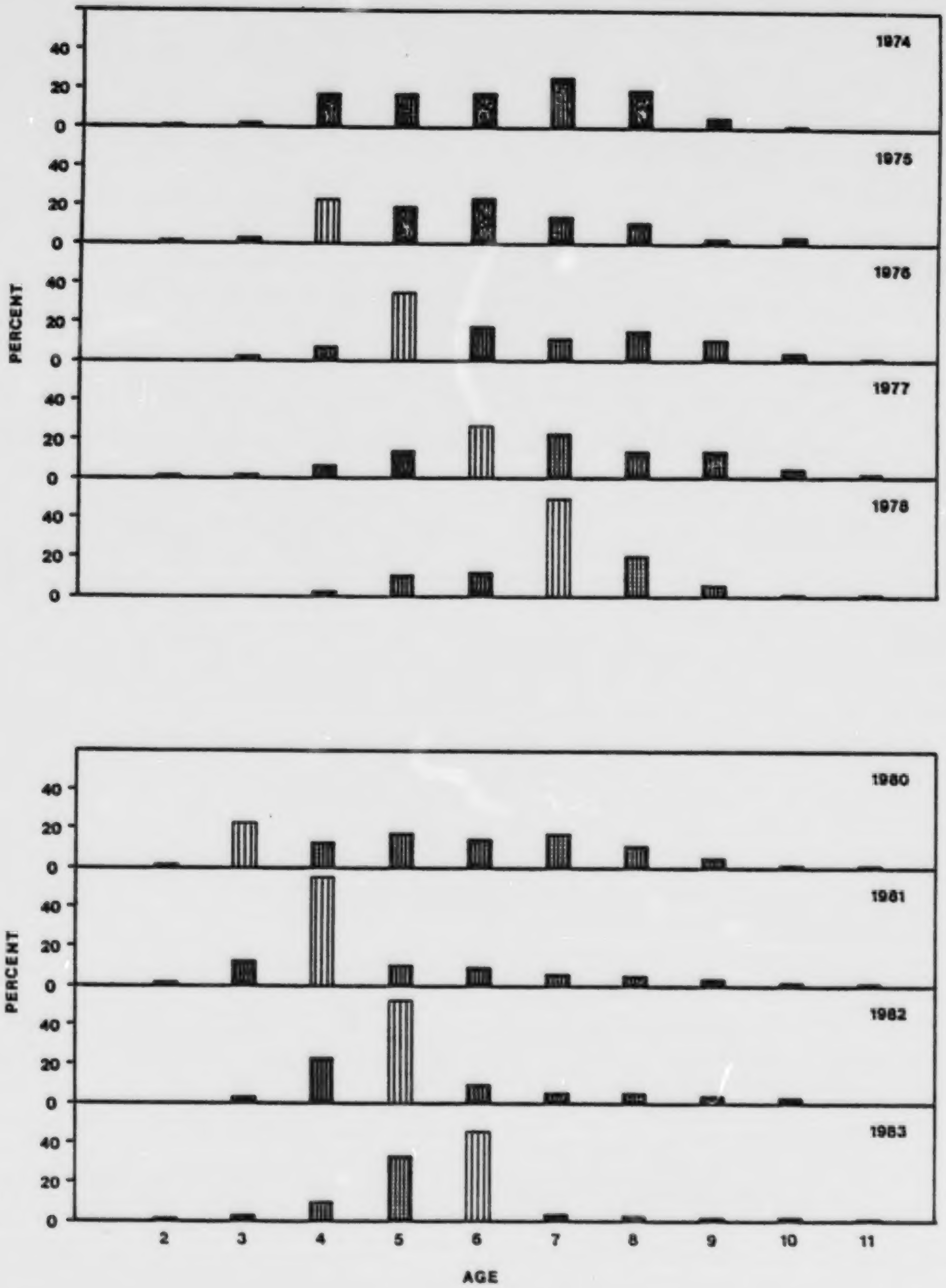

Figure 3.2.1-24. Spring age composition (%) of rock bass in Nanticoke (8- and 10-ft nets pooled) trapnet catches, Long Point Bay, Lake Erie (1974-1983). Values for 1974-1983 are estimated from age-length keys. Bars with vertical stripes highlight strong year classes.

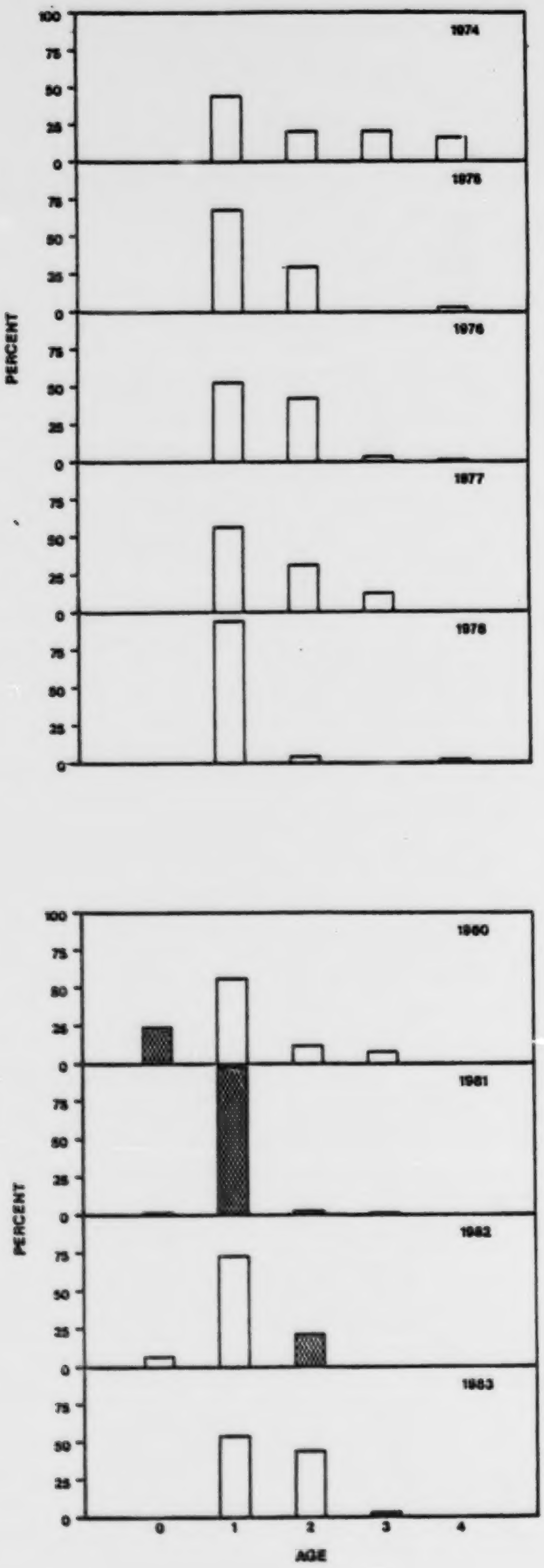

Figure 3.2.1-25. Age composition (%) of white bass in Nanticoke (8- and 10-ft nets pooled) trapnet catches (1974-1983). Data are entirely from aged fish (seasons combined). Cross-hatched bars highlight strong year classes.

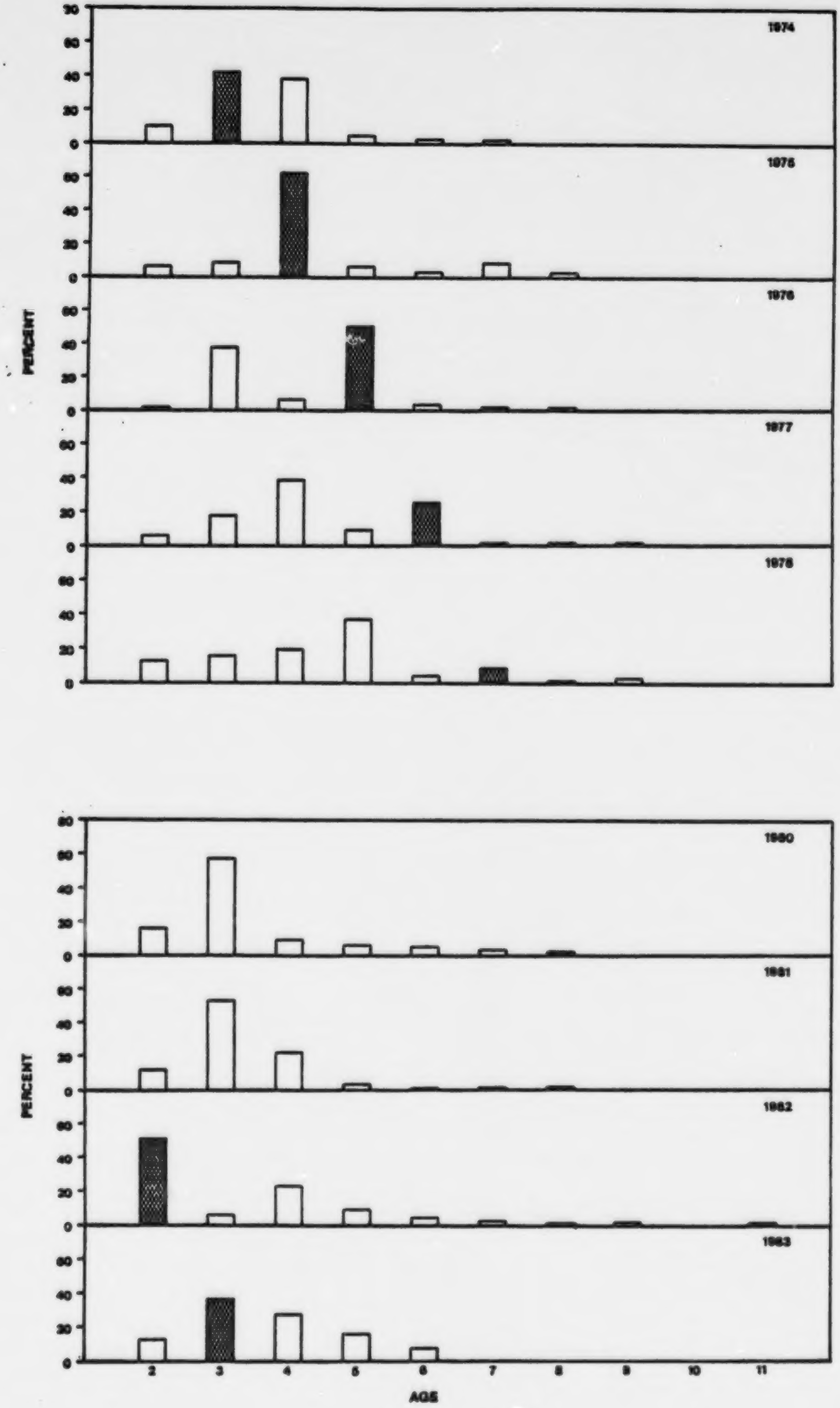

Figure 3.2.1-26. Age composition (%) of smallmouth bass catches in Nanticoke (8- and 10-ft nets pooled) trap nets (1974-1983). Values for the 1974-1978 period are estimated from age-length keys. Cross-hatched bars highlight strong year classes.

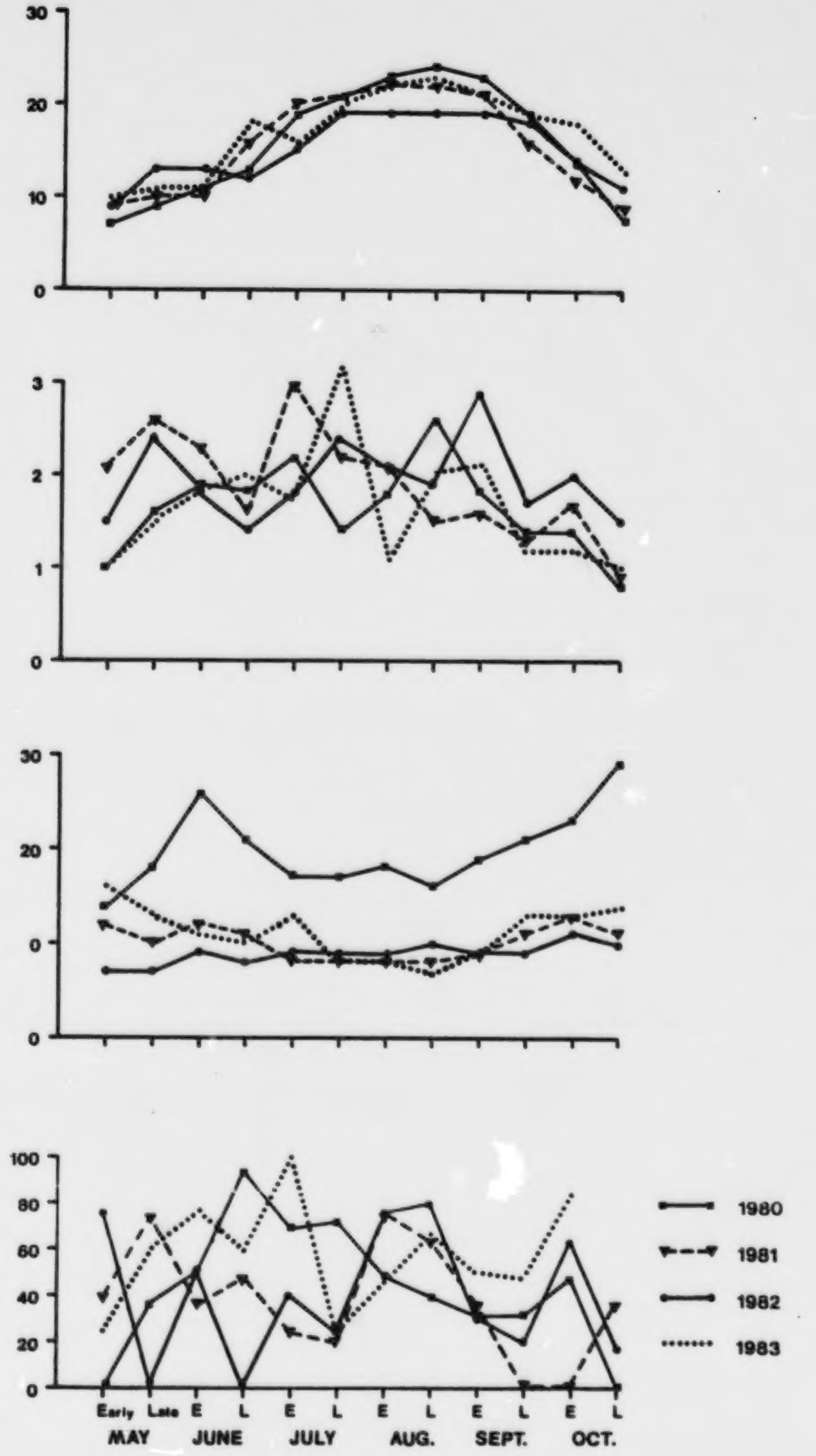

Figure 3.2.1-27. Mean lake temperature, mean secchi transparency, mean wind speed and frequency (%) of onshore winds in the Nanticoke area by half-month intervals from May to October, 1980-1983.

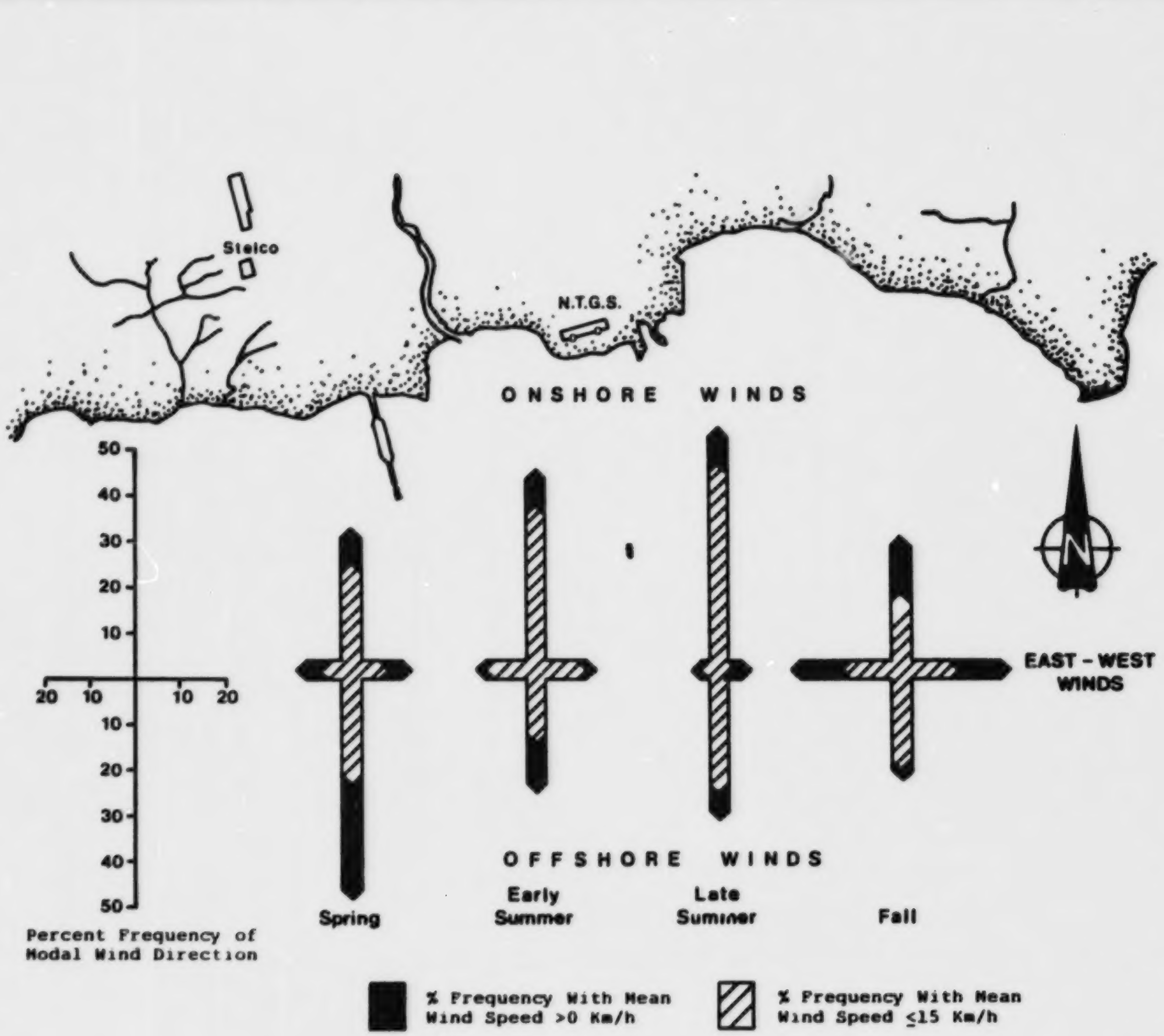

Figure 3.2.1-28. Seasonal occurrence (% frequency) of onshore, offshore and east-west (combined) winds in the Nanticoke area (1980-1983). Wind direction types were defined as follows: onshore winds were from the SE (113-157°), S (158-202°), and SW (203-247°); East-West winds were from the E (68-112°) and W (248-292°); offshore winds were from the NW (293-337°), N (338-360°, 0-22°), and NE (23-67°).

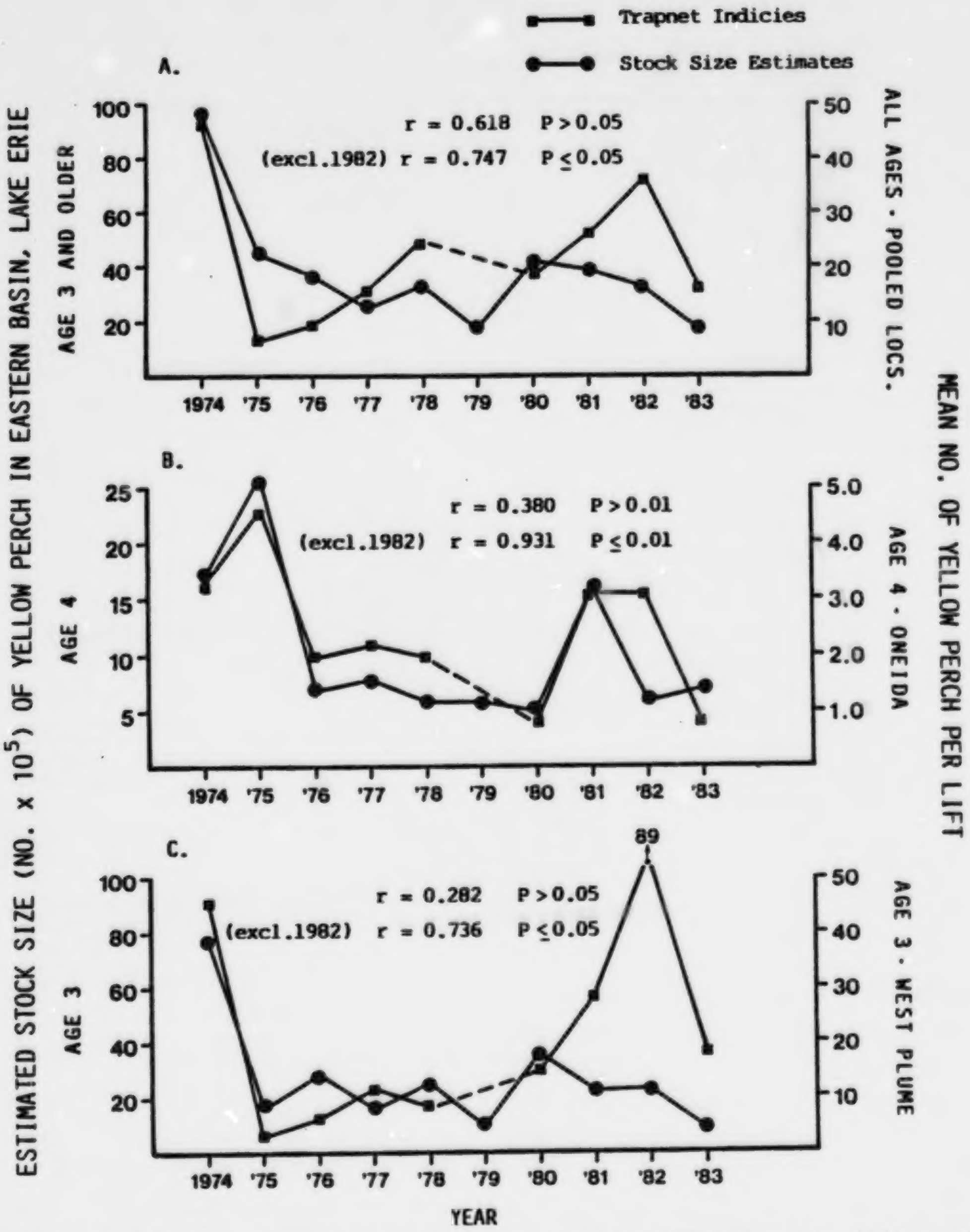

Figure 3.2.1-29. Correlations of mean spring abundance (No./files of yellow perch in Nanticoke trap nets with virtual population (stock size) estimates of yellow perch in Eastern Lake Erie, 1974-1983.

A. pooled trapnet catches (all ages) with stock size of age 3 and older perch;

B. catches of age 4 perch in the Oneida trap net with stock size of age 4 perch;

C. catches of age 3 perch in the West Plume trap net with stock size of age 3 perch.

Dashed lines represent gaps in data series due to discontinued trap netting in 1979. Virtual population estimates were based on cohort analysis (assuming a natural mortality rate of 0.22) derived by the Lake Erie Yellow Perch Task Group.

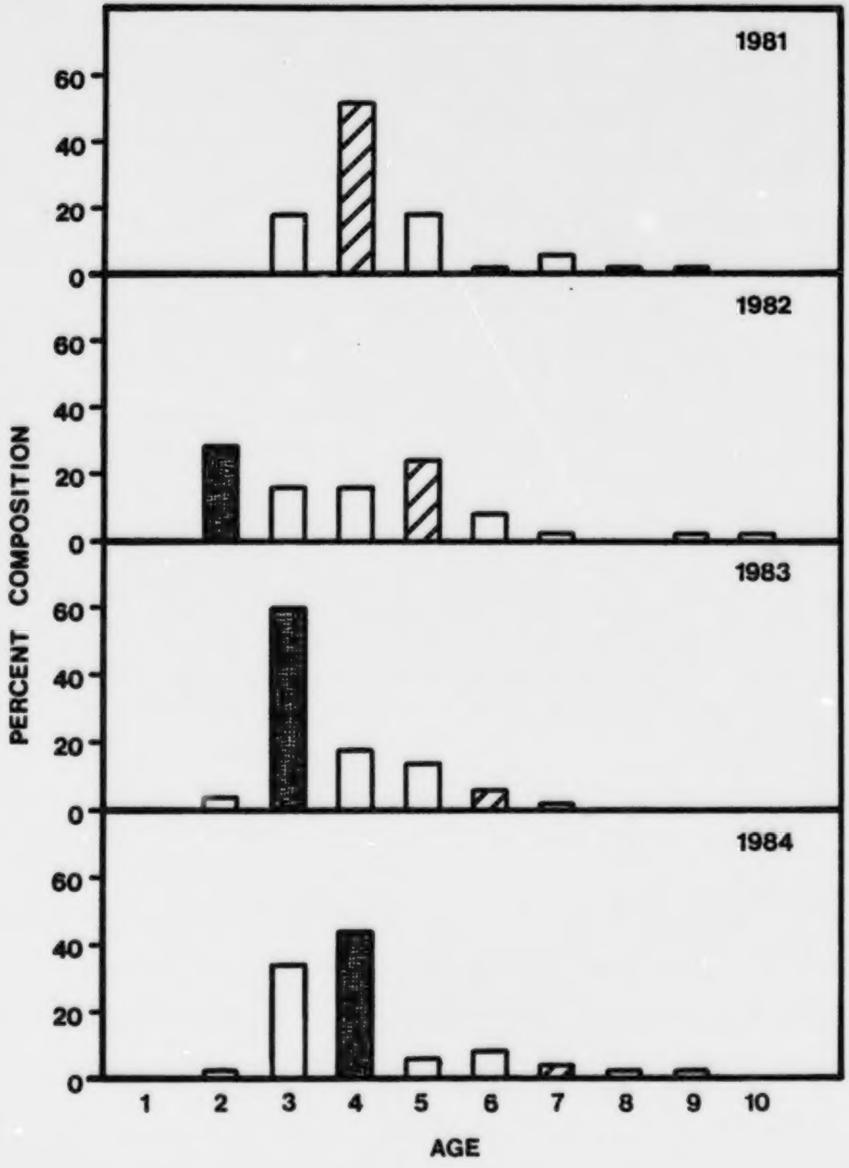

Figure 3.2.1-30. Age composition (%) of smallmouth bass harvested by anglers during the summer sport fishery on Long Point Bay, Lake Erie, 1981-1984. The 1977 year class is highlighted by cross-hatching and the 1980 year class by solid shading.

## 3.2.2 Fish Distribution and Abundance at the Nanticoke Generating Station

### Introduction

Examinations of vertical and spatial distribution of fish in the vicinity of the NTGS plume were carried out on a monthly or biweekly schedule using experimental gill nets (Teleki et al. 1977). In addition, because this study was carried out in a standardized fashion since 1974, the data were used to supplement our examinations of taxonomic composition and annual/seasonal variations in fish abundance at Nanticoke derived from trap nets.

### Methods

#### A. Field Sampling

Two straps of gillnet (each comprised of 50 ft lengths of 1.5-, 4-, 2.5-, 3-, 5-, and 2-in stretched mesh nylon web strung in that order) were set at a "plume" location (near the heated water outfall) and a reference location (loosely referred to as "control" hereafter) some 1.0 km east of the plume site (Figure 3.2.2-1). At each of the two locations, one gillnet strap was set at the surface and the other at the bottom of the water column. From 1974 - 1981 (excluding 1979 and 1980 when no gillnetting was carried out) these straps were set and lifted twice over two contiguous one-day set durations at monthly intervals (usually May - October). In 1982 and 1983 the same procedure was followed but at 2-week intervals.

At each sampling location the numbers of fish caught per mesh size at each net position (i.e. surface or bottom sets) were recorded according to species and their position within the net (i.e. top 1/3, middle 1/3, bottom 1/3). A complete vertical temperature profile (YSI model 51 telethermometer), secchi disk transparency, and meteorological conditions were recorded at each location. From 1981 to 1983 samples of yellow perch, rock bass, white bass, and sport fish (eg. smallmouth bass, walleye, salmon, trout, etc.) were returned to the laboratory where standard morphometrics, sex, and age were determined.

## B. Data Analysis

In addition to the usual descriptive statistics, 4-factor analyses of variance (ANOVA) were performed on the mean catch per lift of the total catch (all fish species pooled), yellow perch, white bass, alewife, and gizzard shad. Catches of these species were transformed first to $\log_{10}$ scores in order to acheive homogeneity of variance (one [1] was added to each catch to avoid taking logarithms of zeros). ANOVA's were performed on least-squares means (LS means), which are the expected value of class or subclass means for a balanced design. All ANOVA's were performed using the SAS GLM procedure (SAS Inst. Inc.). To acheive sufficient cell sizes, catches were grouped into the following 3 "seasons":

spring (April 1 - June 30)
summer (July 1 - August 31)
fall (September 1 - October 31).

Catches of other species were too sparse to satisfy the requirements of ANOVA.

Two 4-factor ANOVA's were performed. The first ANOVA examined years, seasons, locations and net positions as main effects, and a second

ANOVA pooled years into the following two periods:

commissioning period (1974 - 1978)
operational period (1979 - 1983).

Because of the very strong effect of net position on most catches, examinations of yearly, seasonal and spatial effects were supplemented with two independent 3-factor ANOVA's (one for each net position).

Relationships between catch, water temperature and secchi disk transparency were examined by simple correlation analyses of seasonal mean catch ($\log_{10} x + 1$) with seasonal mean water temperature and secchi disk transparency for the 1981-1983 period only. Analyses were performed by separating data from plume and control locations and from surface and bottom net catches. Additional analyses were performed by pooling data from the plume and control locations.

## Results

### A. Species Composition and Vertical Distribution

Twenty-six taxa of fish were observed in the gillnet catches over the study period (1974-1983). The majority of the catch at both locations was comprised of yellow perch, alewife, gizzard shad and white bass (in later years). With few exceptions, the taxonomic compositions of the "catchable community" were similar from year to year, and virtually all of the commonly caught species occurred at both the plume and control locations (Table 3.2.2-1). Notably, two species (white perch and pink salmon) were identified in the catches for the first time in 1981.

Yellow perch consistently dominated the catches of the bottom sets at both locations, representing some 52.5 - 92.2% of the catch annually at the plume and 51.3 - 87.9% at the control locations. Alewife and gizzard shad also were important in the catches of the bottom sets, but the relative proportion of the two species has tended to reverse since 1976 at the plume location and since 1977 at the control site. Gizzard shad and/or alewife dominated the annual catches of the surface nets, although white bass catches have become increasingly important in the surface net catches since 1978 (Table 3.2.2-1).

Only 4 fish species were caught frequently enough to be analyzed separately in addition to the total catch. In most cases, all of the main effects (location, season, year and net position) produced significant effects on the various catches examined (Table 3.2.2-2). Some interactions among the main effects also produced significant effects on the catches but, when compared to the percentage of the variance explained by the important main effects, the effects of interactions generally were minimal.

Net postition had the strongest effect of all factors tested on the total catch and catch of yellow perch, and was important also in the catches of white bass and alewife (Table 3.2.2-2). The net position by year interaction produced significant effects on the total catch and catches of gizzard shad and alewife (Figure 3.2.2-2). The total catch (all fish) of the bottom sets was significantly higher than that of the surface nets ($P = 0.0001$, Figure 3.2.2-3), but recall that the taxonomic composition differed between surface and bottom catches. Yellow perch catches were always significantly higher in the bottom sets than in the surface sets ($P = 0.0001$, Figure 3.2.2-3). Moreover, the majority of yellow perch were caught in the bottom 1/3 to 2/3 of the bottom nets (Figure 3.2.2-4). White bass catches were significantly higher in the surface sets (P = 0.0001) as were the catches of alewife (P = 0.0001, Figure 3.2.2-3). Gizzard shad catches generally were slightly higher (P = 0.0194) in surface nets, but the relatively low percentage of variance explained by net position suggests that shad were distributed throughout the water column (Table 3.2.2-2, Figures 3.2.2-3, and -5).

Statistical comparisons of surface versus bottom catches of other species were impractical because of low catches, but generally most of the minor species occurred most frequently near the lake bottom, with the exception of salmon and possibly walleye (Table 3.2.2-1, Figures 3.2.2-6, and -7).

### B. Location

The effect of location on catches was weakly significant in the 4-factor model for most groups, and in all cases where significance occurred the catches were highest at the plume (Tables 3.2.2-2, and -3; Figure 3.2.2-8B). The total catch was highest at the plume location in both surface and bottom sets (P = 0.0001, Table 3.2.2-4, Figures 3.2.2-8B, and -9). Location produced a strong effect only on the bottom catches of yellow perch, which were significantly highest at the plume (Table 3.2.2-4, Figures 3.2.2-8B, and -9). Catches of gizzard shad and alewife tended to be highest at the plume but this varied from year to year (Figures 3.2.2-9), and was statistically insignificant for both species in the surface nets. Gizzard shad catches were significantly higher at the plume (P = 0.0051) in the bottom nets (Tables 3.2.2-4, and -5). White bass catches were higher at the plume location in the surface nets, but the difference was only marginally significant (P = 0.0341, Figures 3.2.2-8B, and -9).

C. Season

Season produced highly significant effects on the catches of all groups tested (Table 3.2.2-4) regardless of net position, and some rather clear-cut trends in seasonal catches were apparent. Statistical tests among seasons were made by inspection of probability matricies of the hypotheses: LSM ($\text{season}_x$) = LSM ($\text{season}_y$) using pooled locations and years. Regardless of net position, gizzard shad catches increased strongly and progressively from spring to fall each year and at each location (Figures 3.2.2-2, and -8A) and fall catches generally were significantly higher than the previous two seasons (P = 0.0001). The strong, consistent effect of season on gizzard shad catches is emphasized in the ANOVA results where season produced the strongest of all effects. On the other hand, seasonal trends in alewife catches, while variable from year to year, were usually significantly lowest in the fall (P = 0.0001) and tended to be highest in summer (Figure 3.2.2-2, and -8A). Seasonal trends in yellow perch catches were quite variable from year to year (Figure 3.2.2-2), although the catches tended to be significantly highest in summer (P = 0.0023, Figure 3.2.2-8A). The low catches of white bass in the earlier years (Figure 3.2.2-3) hampered detection of seasonal trends in catches; however, catches tended to increase from spring to fall (Figure 3.2.2-8A) and were significantly highest in the fall (P = 0.0143).

## D. Year and Period

Significant differences (P = 0.0001) were detected among years in the catches of all fish, alewife, gizzard shad and white bass (Table 3.2.2-3, Figures 3.2.2-3, and -9). While year produced a weakly significant effect on yellow perch catches in the 4-factor model (P = 0.0123), there was no significant difference among years in the bottom catches where the vast majority of perch were caught (Table 3.2.2-4, Figures 3.2.2-3, and -9). Considering pooled catches from both net positions, only gizzard shad and white bass catches differed significantly (P = 0.0001) between the preoperational and operational periods, and both were significantly higher in the operational period (Tables 3.2.2-6, and -7).

Significant year by season interactions were detected for all groups in the 4-factor ANOVA (Table 3.2.2-2), and for all groups in the 3-factor ANOVA for the net position in which catches were highest (Tables 3.2.2-3, and -4).

## E. Size and Age Composition

Age, length and weight data were available from gillnet catches only for the period 1981 - 1983 and only for yellow perch, white bass and smallmouth bass.

Catches of yellow perch were predominately age II at both locations, ranging from 33.8 to 81.7% of the total perch catch in a given year (Tables 3.2.2-8, -9, and -10). The 1982 yellow perch catch was dominated by both age II and age III fish at both locations (Figure 3.2.2-10) because the 1980 year class was relatively weak, and because of continued prominence of the 1979 year-class (age III) in that year (the 1979 year-class is considered to have been a relatively strong year-class, OMNR 1981, 1982). Growth of yellow perch occurred over all three seasons at both locations but growth tended to be fastest between summer and fall (Tables 3.2.2-11, -12, and -13 Figure 3.2.2-11). Female yellow perch typically were larger at age than males, and perch tended to be smaller at the plume location (Figures 3.2.2-12, and -13).

By comparison with samples of yellow perch, sample sizes of white bass and smallmouth bass were small. White bass catches were dominated by age I and/or age II fish, but the 1980 year class was prominent in all 3 years (Figure 3.2.2-14). Catches of smallmouth bass were dominated by age II and/or age III fish (Figure 3.2.2-15). The small sample sizes of these two species precluded detailed appraisal of growth among locations or sexes.

### F. Relationships Between Catch, Temperature and Water Clarity

Seasonal mean water temperatures differed slightly between the plume and control locations (Table 3.2.2-14). The differences were most pronounced at the surface where water temperatures averaged about 1°C warmer at the plume site. Bottom temperatures were slightly cooler (usually <1°C) at the plume location.

The catches of several fish species were significantly correlated with mean water temperatures on a seasonal basis (Tables 3.2.2-15 and -16). Surface net catches of alewife were negatively correlated with water temperature at both the plume and control locations in summer. Catches of gizzard shad were positively correlated with water temperatures in summer and fall at both locations; these relationships existed both for catches in surface and in bottom net catches. Bottom catches of yellow perch were positively correlated with water temperature in the fall at both locations. Spring catches of white bass and smallmouth bass respectively were positively and negatively correlated with water temperature, but were evident only when locations were combined and only for bottom catches. In summer, bottom catches (pooled locations) of smallmouth bass were slightly positively correlated with bottom temperature as were bottom catches of freshwater drum in summer and fall.

The relationships between catch and water clarity (secchi disk transparency) generally were negative, and in all cases where statistically significant correlations existed, the relationship was negative.

## Discussion

### A. Vertical Distribution

The results of the gillnet study confirmed that different species of fish inhabit different portions of the water column. Yellow perch were strongly associated with the lake bottom at Nanticoke in all seasons sampled, whereas alewife, white bass and, to some extent, gizzard shad occurred more frequently near the surface. Most of the other less abundant species in the catches tended to be distributed near the lake bottom, including smallmouth bass, rock bass, freshwater drum, catfish (Ictalurids) and suckers.

Our observations of vertical fish distribution at Nanticoke were similar at both the plume and control locations, and are consistent with observations of these species in other water bodies. Those species occurring most frequently in our surface net catches (eg. alewife, gizzard shad and white bass) have been shown to be typically pelagic feeders (Brandt 1980, Miller 1960, Scott and Crossman 1973, Wells 1980), whereas those species occurring most frequently in the bottom catches have been shown to be demersal in feeding habit (eg. brown bullhead, rock bass, smallmouth bass and freshwater drum) (Scott and Crossman 1973). Gizzard shad appeared to be distributed throughout the water column at Nanticoke with only a slight tendency to concentrate near the surface. Gizzard shad typically are described as an open-water, pelagic species living near the surface, but the species is known to inhabit both shallow and deeper waters as we observed at Nanticoke (Miller 1960 and references therein).

The observed strong concentration of yellow perch at the lake bottom in Nanticoke waters (Figure 3.2.2-4) corroborates the findings of Berst and McCombie (1963) who found that some 80% of yellow perch caught by experimental gill nets in South Bay, Lake Huron were taken within the first 30 cm above the lake bottom. The aforementioned authors suggest that this distribution is consistent with nocturnal behavior of yellow perch as observed by Hasler and Villemont (1953) in Lake Mendota. Similarly, Bartoo (1972) found that perch were invariably found within a few feet of the bottom in Lake Washington, regardless of water depth or season. However, yellow perch exhibit both pelagic and demersal distributions in other waters depending on diel period, age/size of the fish, season and temperature (Ferguson

1958; Hergenrader and Hasler 1967, 1968; Hasler and Tibbles 1970; Hokanson 1977). In addition, factors such as light and food availability may also be important in determining the vertical distribution of perch (Rudstam and Magnuson 1985). Examination of the available length data from the gillnet catches (1981 - 1983) revealed that by far the dominant size range of yellow perch (generally > 90% of the catch) was that in which perch exhibited predominately demersal feeding (i.e. feeding principally on benthic organisms; see Section 4.1). In the larger size classes, yellow perch were more pisciverous and pelagic distribution may be more common at this size (this could not be tested in our data because of low catches in the surface nets).

Clearly, therefore, our gillnet catches reflect the vertical distribution of a given species only for the age/size classes most vulnerable to our gear. Moreover, our results are from gill nets set over a 24-hour period and, therefore, reflect only the average (most frequent) daily depth distribution. Diel changes in vertical distribution have been documented for many freshwater fish species. For example, Hasler and Villemont (1953) described diel movements of yellow perch from deeper to shallower water just prior to sundown; reverse movements were noted at sunrise. Similar observations were made by Engel and Magnuson (1976) for perch in Pallette Lake, Wisconsin.

## B. Seasonal and Spatial Distribution

The observed seasonal variations in fish catches at Nanticoke clearly demonstrated seasonal increases or decreases in the susceptibility of some fish species to our gear. These seasonal trends could be due to seasonal movements into or out of the sampling area, seasonal changes in activity, recruitment of younger age classes into the gear or a combination of these and other factors. Because the late-summer and fall increases in gizzard shad catches occurred clearly and consistently in most years in both surface and bottom catches, the trend is attributed to increased abundance of size groups susceptible to our nets at this time. Similar late summer and fall increases in gizzard shad catches were observed by Hesse _et_ _al_. (1982) and Miller (1960); both studies attributed this to the abundance of vulnerable age 0 fish at this time. Seasonal trends in the catches of other taxa were more variable from year to year and may have been related as much to seasonal variability in activity, or to seasonal recruitment of younger age classes into the gear, as to abundance.

Clearly, fish did congregate in the vicinity of the outfall as total fish catches and catches of yellow perch, white bass and gizzard shad were significantly higher at the plume location, particularly in the later years. Concentrations of fish near the outfall were not unexpected as this appears to be a common observation at many power sites (Coutant 1970, Neill and Magnuson 1974, Spigarelli _et_ _al_. 1982, Langford 1983), but the causes of the phenomenon are as yet not clearly explicable (Langford 1983). Part of the attraction may be temperature-related, but differences in mean temperature between the plume and control sites at Nanticoke were slight, and detectable only at the surface (because of the floating nature of the plume) where temperatures averaged only about 1°C warmer at the plume site (Table 3.2.2-14).

The data are not amenable to detailed analyses of thermal responses to the plume in comparison to the reference area. However, significant positive correlations between water temperatures and gillnet catches of yellow perch (fall), white bass (fall), alewife (fall), and particularly gizzard shad (summer and fall) were detected (Table 3.2.2-15), but in most instances these correlations occurred both at the plume and control sites (Table 3.2.2-16). This, combined with the fact that seasonal fluctuations in abundance at the plume typically were paralleled at the control site, suggests that the presence of most species in the outfall area are related to their presence in other nearshore areas. Thus, seasonal inshore movements (perhaps induced by ambient thermal conditions) would seem to be more responsible for the presence of fish at the outfall than discharge temperature. For example, alewife catches at Nanticoke typically were highest in summer at both the plume and control locations, and closer inspection of the data revealed that catches peaked at both sites in late June or July. This corresponds to the spawning period for alewife, and similar late-June/July peaks in inshore abundance during spawning have been shown in several other studies (Dahlberg 1981, Graham 1956, Wells 1968). Spigarelli *et al*. (1982) have also shown that alewife congregate within and near thermal plumes during the spawning period, suggesting that this species is attracted to plumes during spawning, but avoids them in other seasons.

At Nanticoke, alewife catches were significantly, but negatively correlated with temperature in summer at both locations, which probably reflects the lower preferred temperature of the species in summer (16°C) and corresponds with annual offshore migrations (Otto *et* al. 1976, Wells 1968). That alewife catches were positively correlated with temperature in fall provides further support for the findings of Wells (1968) and Otto et al. (1976) who reported that alewife gradually moved offshore to deeper water as lake temperatures decline. However, the possibility that a reduction in fish activity as temperatures declined may have reduced their susceptibility to the gear cannot be overlooked in this instance.

Gizzard shad in particular are attracted to warmwater discharges (Miller 1960, Gammon 1971, Scott and Crossman 1973, Talmage and Opresko 1981, Hesse et al. 1982) and the strong summer and fall attraction (higher catches at the plume site) of this species to the NTGS outfall area observed in this study, and by Wianko and Dixon (1983), was not surprising. Correlations of gizzard shad catches with temperature were among the strongest and most consistent that we observed. However, the correlations were significant both at the plume and control sites, and MacGregor (1984) observed high correlations of gizzard shad catches with temperature over very narrow temperature ranges in western areas of Long Point Bay (some 20 km removed from the Nanticoke study area). Thus, increased summer and fall catches of this species, while apparently temperature-related, probably are a phenomenon characteristic of the entire basin, perhaps associated with general inshore movements by the species in search of optimal thermal conditions, and to the increased vulnerability or local abundance of young fish at this time (Miller 1960, Hesse et al. 1982).

Although not conclusive, observed higher catches of shad in thermal outfalls would seem to be a mere magnification of the tendency to move inshore to warm water. That correlations continued to be positive in fall suggests that shad moved offshore to deeper, warmer water as temperatures declined, a behaviour which appears to be common among warmwater species (Wells 1968). Gizzard shad exist at the northern edge of their range in Lake Erie and congregations of this species in heated water may reflect the use of such areas as a thermal refuge in an attempt to avoid the extreme temperatures of winter. This contention is supported by observations of Wianko et al. (1983) who reported that gizzard shad were found exclusively in the plume in winter and were virtually absent in reference areas. White et al. (1986) attributed heavy winter mortalities of this species in Lake Erie to specific physiological traits which are maladapted to winter temperatures (eg. enzymatic failure during rapidly declining temperatures leads to winter starvation when lipids cannot be mobilized).

Despite evidence from the NTGS creel census (Section 3.2.5), which clearly demonstrates congregations of white bass at the NTGS plume in late spring, gillnet catches of this species typically were low in all seasons and did not peak until fall. This is likely an artifact arising from the location of our plume site. Bass congregated directly in the discharge channel for spawning (see Section 3.2.5), whereas our test net was situated some 250 m from the channel. Apparently neither our gill nets nor trap nets were situated in locations where the bass congregated in spring, and thus the catches may not adequately reflect seasonal distribution of the species here. However, because surface gillnet catches typically were significantly higher at the plume location, the data do support the contention that white bass are attracted to the area.

Yellow perch were more abundant at the plume than at the control site in all three seasons, but no significant relationship between catch and temperature was detected until fall. During fall, the observed highly significant, positive correlations with temperature suggest that the same process occurred in fall with yellow perch as occurred with gizzard shad and alewife; that is, as temperatures declined perch moved offshore to deeper, warmer water. Schaefer (1977), Dahlberg (1981) and Wells (1968) have reported similar offshore movements by perch in October. That peak catches tended to occur at both sites in summer probably is a function of greater activity (Dahlberg 1981, Hergenrader and Hasler 1967) and denser schooling behavior (Hergenrader and Hasler 1968) by perch during warmer months, thereby increasing their vulnerability to the passive gear (Dahlberg 1981).

Clearly, perch were attracted to the NTGS outfall area but the stimuli to which they were responding was unclear. In view of the strong association of perch with the bottom, it is unlikely that the response was due to elevated temperatures of the discharge channel because temperatures in deeper waters at the plume site were similar, or even slightly cooler than at the control location. This is not surprising as the floating, overflow nature of the plume at Nanticoke would tend to develop a counter current of cooler water underneath (McNeely and Pearson 1974, 1977). The importance of temperature in determining perch distribution is particularly unclear. While studies by Neill and Magnuson (1974), Hubert and Sandheinrich (1983) and Brandt _et_ _al_. (1980) emphasize the importance of temperature in regulating perch distribution, other studies such as those by Ross and Siniff (1982) and Rudstam and Magnuson (1985) suggest that factors other than, or in addition to, temperature influence spatial distribution. It would appear that temperature, when acting in concert with many other dynamic environmental variables, does not influence perch distribution to the extent that laboratory experiments predict (Ross and Winter, 1981).

It is unlikely that temperature alone accounts for the concentration of many fish species in thermal discharges, although there is a large body of evidence suggesting that temperature is the controlling factor (Talmage and Opresko 1981, Neill and Magnuson 1974). Other factors such as food availability and habitat differences may have contributed to the observed plume-control differences. For instance, diving observations carried out in 1985 revealed that 100% of the bottom at the plume site was comprised completely of a deep layer of soft muck (silt and clay particles) whereas some 55% of the 'control' site contained boulder, cobble and gravel; the remainder being sand (20%) and silt or clay (25%). In addition, there is evidence that zooplankton (Carter and Sardella 1985) and benthic organisms (see Section 4.1) are more abundant at the NTGS outfall. We have little quantitative information concerning forage fish abundance at Nanticoke but visual observations of large schools of minnows at the plume are common. Indeed, in 1982, experimental trawling with a 10 m (head-rope) Biloxi trawl at the plume yielded as many as 50,000 emerald shiners in a single 10-min. tow (OMNR 1982, unpublished data). Aggregations of forage fishes at thermal plumes can be expected in view of the findings of Prince and Mengel (1981), and Storr and

Schlenker (1974) who have reported concentrations of spottail shiners and other forage fish in similar heated waters.

Whatever the causes of the observed seasonal fluctuations in gillnet catches of the species examined, it is apparent that they are not due to discharge from the power plant, as parallel fluctuations invariably occurred both at the plume and control sites for all species. Significant negative correlations between fish catch and secchi disk transparency frequently were detected (Table 3.2.2-15), suggesting that vulnerability to the gear declines as water clarity improves. As water clarity is related to seasonal weather conditions (wave action, rainfall, etc.) (see Section 3.2.2 and MacGregor 1984), some of the seasonal variability in catch is undoubtedly a simple reflection of seasonal changes in climatic conditions that influence vulnerability to the gear and gear efficiency. As noted earlier, the effects of temperature on fish activity are also important in this respect.

While only one 'control' and one test location make plume-control comparisons somewhat suspect, as variability within control and test locations could not be examined, the results corroborate findings of other components of our work in that several species appeared to congregate near the NTGS outfall in both the upper and lower strata of the water column. These observations would appear to be conservative in indicating the magnitude of plume-control differences in fish density because the plume site was situated at the edge of the plume current some 250 m from the actual channel. Although this site was still obviously within the influence of the outfall current, strong currents at the outfall jet prevented situating the nets any closer.

We expect that catches of at least white bass and perhaps other species (alewife and gizzard shad) would have been considerably higher had the test nets been set closer to the channel (although perch catches may have declined in this situation as the species tends to prefer peripheral areas of thermal discharges; Ross and Winter 1981).

### C. Yearly Trends in Abundance

Indices of abundance for many fish species fluctuated significantly over the study period, but detection of trends through time were hampered by lack of information pertaining to the age distribution of the catch in the earlier years. While age data is available only for the period 1981-1983, (and only for a few species) it is clear from inspection of these results that year-class strength will strongly influence the year-to-year catches, particularly since only one, or at most two, age classes seemed to dominate the catches of most species. Ideally, year-to-year comparisons should be stratified by age class but this was not possible because of the lack of age or length data for the pre-1981 gillnet catches. While no trend in perch abundance over the study period was detected in the gillnet catches, these analyses have demonstrated several other changes in recent years, including an increased abundance of white bass during the operational period, a new presence of white perch since 1981 and an increased abundance of gizzard shad in recent years. These observations occurred at both the plume and control locations and, more importantly, the same trends have been observed throughout Lake Erie in commercial fish catches.

Inspection of Table 3.2.2-17 demonstrates a clear increase in the 1982 and 1983 commercial landings of white bass in Long Point Bay and Lake Erie in general, suggesting a lake-wide increase in abundance of this species. The recent increases in white bass catches may be due largely to the 1980 year class, which was quite strong throughout Lake Erie (OMNR 1981) and showed a strong presence in our 1981 - 1983 gillnet catches at Nanticoke.

White perch were first reported in commercial landings from Lake Erie in 1981, the year in which we first noted them in our gill nets. The significantly higher catches of gizzard shad in the operational years were due to unusually high catches in 1983, a phenomenon noted throughout Long Point Bay and Lake Erie (MacGregor 1984, OMNR 1984), and again this was due to a particularly strong year class. Therefore, the major shifts in year-to-year abundances noted in our gillnet catches were not due to industrialization; rather, they simply reflect differences in year class strengths arising from conditions occurring throughout Long Point Bay and Lake Erie in general.

## Summary

Experimental gill nets comprised of six different mesh sizes from 1.5 to 4.0 inches were fished 2 to 4 times (24-h sets) monthly near the lake surface and bottom at the Nanticoke TGS plume, and at a reference site, to determine the vertical and horizontal distribution of fishes near the thermal discharge. Log-transformed catches of the most abundant species and total catch were examined by four- and three-factor ANOVA models for effects due to year (1974-1983), season, location and net position.

Some 26 taxa were captured over the survey period of which yellow perch, alewife, gizzard shad, and in the latter years, white bass were dominant. Variations in catches of these species and total catch due to the main effects and some interactions were statistically significant.

In the four-factor models, net position accounted for most of the variability in catches of yellow perch, which represented more than half the total catch in bottom-set gill nets at the plume (53-92% of annual total catch) and reference site (51-88% of annual total catch). Net position also explained a significant portion of the variation in white bass and alewife catches. These species, and to some extent gizzard shad, were captured more frequently in surface than bottom sets. Vertical segregation was evident between those species exhibiting largely demersal feeding tendencies (eg. yellow perch), and pelagic feeders (eg. alewife, white bass).

Seasonal variations in catches of the major species were due to seasonal movements of fish to and from the study area, changes in activity, and recruitment. For example, peak catches of gizzard shad in late summer and fall were attributed to recruitment of young fish into the gear, and peak catches of alewife in late June or July coincided with the inshore spawning migration of this species.

Fish congregated in the vicinity of the NTGS outfall, particularly in the operational years, but the exact reasons are not known. Catches of yellow perch, gizzard shad and alewife were positively correlated with water temperature. The relationship of catch with water temperature was strongest in fall, especially for gizzard shad, suggesting that fish moved offshore into deeper water as the lake cooled.

Year - to - year fluctuations in abundance were significant but could not be examined in detail because of inadequate age composition data. Abundance indices of some species were susceptible to large annual variations because catches were comprised largely of only one or two age classes. Observed annual fluctuations in catches apparently were not due to industrial activities, but were more probably related to variations in year-class strengths experienced lakewide.

Table 3.2.2-1. Taxonomic composition of gillnet catches at Nanticoke, Long Point Bay, Lake Erie (1974-1983).

|  | % Composition |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | 1974 |  | 1975 |  | 1976 |  | 1977 |  | 1978 |  | 1981 |  | 1982 |  | 1983 |  |
| SPECIES | Surface | Bottom | Surface | Bottom | Surface | Bottom | Surface | Bottom | Surface | Bottom | Surface | Bottom | Surface | Bottom | Surface | Bottom |
|  |  |  |  |  |  |  |  |  | PLUME |  |  |  |  |  |  |  |
| Rainbow Smelt | 7.45 | 14.72 | 4.97 | 2.07 | 5.10 | 2.86 | 8.46 | 9.73 | 24.19 | 1.32 | 0.00 | 1.38 | 2.62 | 2.85 | 0.25 | 0.71 |
| Yellow Perch | 4.18 | 59.65 | 4.59 | 62.51 | 2.04 | 70.00 | 4.07 | 52.52 | 10.82 | 82.10 | 32.94 | 92.21 | 5.25 | 76.00 | 0.38 | 56.47 |
| White Bass | 2.09 | 0.76 | 1.48 | 0.15 | 3.74 | 0.41 | 0.88 | 0.50 | 0.00 | 1.32 | 38.82 | 0.39 | 12.62 | 1.49 | 10.06 | 1.28 |
| White Perch | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.49 | 0.16 | 3.07 | 0.76 | 1.66 |
| Smallmouth Bass | 0.00 | 0.76 | 0.26 | 0.15 | 0.00 | 1.63 | 0.00 | 0.50 | 0.00 | 0.66 | 0.00 | 0.30 | 0.00 | 1.59 | 0.13 | 0.16 |
| Rock Bass | 0.13 | 1.40 | 0.13 | 0.08 | 0.00 | 1.02 | 0.00 | 2.35 | 0.00 | 0.99 | 0.00 | 0.20 | 0.00 | 0.17 | 0.00 | 1.28 |
| Walleye | 0.00 | 0.13 | 0.00 | 0.08 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 | 0.00 | 1.64 | 0.08 |
| Chinook Salmon | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 | 0.11 | 0.00 | 0.00 |
| Pink Salmon | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.38 | 0.00 |
| Freshwater Drum | 0.65 | 2.92 | 0.00 | 0.92 | 0.00 | 1.63 | 0.00 | 1.51 | 0.00 | 2.65 | 0.00 | 0.85 | 0.00 | 2.44 | 0.00 | 2.68 |
| Alewife | 81.96 | 11.80 | 58.80 | 25.10 | 86.05 | 4.69 | 1.75 | 0.84 | 12.90 | 2.81 | 1.53 | 0.00 | 31.97 | 0.53 | 44.65 | 9.76 |
| Gizzard Shad | 2.48 | 0.89 | 28.83 | 6.43 | 2.72 | 13.88 | 83.09 | 26.34 | 42.47 | 2.65 | 12.94 | 1.58 | 46.56 | 6.34 | 41.26 | 24.29 |
| White Sucker | 0.13 | 4.44 | 0.38 | 1.00 | 0.00 | 1.22 | 0.00 | 2.01 | 0.00 | 2.98 | 9.41 | 1.18 | 0.00 | 1.91 | 0.00 | 1.18 |
| Stonecat | 0.00 | 1.52 | 0.00 | 0.23 | 0.00 | 0.00 | 0.00 | 1.68 | 0.00 | 0.50 | 0.00 | 0.39 | 0.00 | 0.42 | 0.00 | 0.24 |
| Yellow Bullhead | 0.00 | 0.13 | 0.00 | 0.15 | 0.00 | 0.20 | 0.00 | 1.51 | 0.00 | 0.00 | 0.00 | 0.99 | 0.00 | 0.00 | 0.00 | 0.08 |
| Redhorse Sucker | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 | 0.11 | 0.00 | 0.08 |
| Carp | 0.26 | 0.13 | 0.00 | 0.15 | 0.34 | 2.25 | 0.00 | 0.17 | 0.00 | 0.33 | 0.00 | 0.00 | 0.00 | 0.21 | 0.13 | 0.00 |
| Rainbow Trout | 0.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 |
| Trout Perch | 0.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 |
| Crappie | 0.00 | 0.13 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 |
| Northern Pike | 0.00 | 0.13 | 0.38 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mooneye | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 |
| Coho Salmon | 0.00 | 0.00 | 0.51 | 0.08 | 0.00 | 0.00 | 0.00 | 0.17 | 0.54 | 0.17 | 1.18 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 |
| Brown Bullhead | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Brown Trout | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 |
| Lake Trout | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
|  |  |  |  |  |  |  |  |  | CONTROL |  |  |  |  |  |  |  |
| Rainbow Smelt | 2.07 | 1.82 | 11.84 | 5.83 | 1.47 | 1.29 | 17.32 | 5.83 | 62.79 | 6.36 | 19.40 | 0.74 | 4.84 | 1.44 | 0.27 | 0.34 |
| Yellow Perch | 11.03 | 59.84 | 11.84 | 54.14 | 5.86 | 73.23 | 2.41 | 55.78 | 0.00 | 62.19 | 14.13 | 87.85 | 4.84 | 72.42 | 0.54 | 51.31 |
| White Bass | 2.76 | 0.00 | 0.99 | 0.15 | 1.10 | 1.29 | 2.28 | 0.00 | 13.95 | 1.77 | 23.88 | 1.29 | 23.39 | 1.44 | 4.76 | 1.37 |
| White Perch | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.83 | 0.57 | 0.27 | 0.80 |
| Smallmouth Bass | 0.46 | 1.98 | 0.00 | 0.61 | 0.00 | 1.29 | 0.00 | 1.24 | 0.00 | 6.36 | 0.00 | 1.84 | 0.00 | 4.71 | 0.07 | 3.30 |
| Rock Bass | 0.00 | 1.49 | 0.00 | 0.27 | 0.00 | 0.00 | 0.00 | 2.17 | 0.00 | 1.77 | 0.00 | 1.67 | 0.40 | 2.04 | 0.00 | 0.80 |
| Walleye | 0.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.40 | 0.11 | 0.41 | 0.23 |
| Chinook Salmon | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.11 |
| Pink Salmon | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.40 | 0.00 | 0.00 | 0.11 |
| Freshwater Drum | 0.69 | 6.28 | 0.33 | 2.15 | 0.00 | 5.18 | 0.00 | 5.28 | 0.00 | 3.53 | 0.00 | 2.76 | 0.00 | 4.71 | 1.36 | 6.26 |
| Alewife | 77.93 | 14.88 | 71.68 | 27.91 | 87.91 | 11.61 | 2.29 | 0.00 | 6.40 | 0.71 | 7.46 | 0.00 | 19.36 | 2.15 | 45.38 | 14.45 |
| Gizzard Shad | 2.76 | 2.81 | 0.66 | 4.29 | 2.20 | 0.65 | 72.88 | 24.85 | 14.54 | 5.30 | 14.93 | 2.21 | 36.29 | 1.70 | 46.13 | 15.13 |
| White Sucker | 0.23 | 10.58 | 0.66 | 2.76 | 0.00 | 3.55 | 0.00 | 0.00 | 0.00 | 6.71 | 0.00 | 1.29 | 3.23 | 6.01 | 0.34 | 5.01 |
| Stonecat | 0.23 | 0.33 | 0.00 | 0.61 | 0.00 | 0.32 | 0.13 | 0.93 | 0.00 | 1.41 | 0.00 | 0.55 | 0.00 | 0.52 | 0.00 | 0.23 |
| Yellow Bullhead | 0.00 | 0.00 | 0.00 | 0.00 | 0.73 | 0.65 | 0.00 | 0.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 |
| Redhorse Sucker | 0.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.47 | 0.00 | 0.00 | 2.42 | 0.78 | 0.00 | 0.34 |
| Carp | 0.46 | 0.00 | 0.00 | 0.77 | 0.37 | 0.00 | 0.13 | 0.31 | 0.00 | 0.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Rainbow Trout | 0.69 | 0.00 | 0.00 | 0.00 | 0.37 | 0.00 | 0.00 | 0.00 | 0.58 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 |
| Trout Perch | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 0.00 |
| Crappie | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Northern Pike | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mooneye | 0.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 | 0.00 |
| Coho Salmon | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.65 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.81 | 0.00 | 0.20 | 0.00 |
| Brown Bullhead | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Brown Trout | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Lake Trout | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 0.00 |

Table 3.2.2-2. Analysis of variance (4-factor model) of log transformed ($\log_{10}$ x + 1) gillnet catches at Nanticoke, Long Point Bay, Lake Erie (1974-1983)¹ .

| SOURCE OF VARIATION | | | SPECIES | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ALL FISH | | | | YELLOW PERCH | | | | ALEWIFE | | | | GIZZARD SHAD | | | | WHITE BASS | | | |
| | | df | SS | MS | F | P | SS | MS | F | P | SS | MS | F | P | SS | MS | F | P | SS | MS | F | P |
| Main effects: | Location | 1 | 1.433 | 1.433 | 7.95 | 0.0050 | 1.168 | 1.168 | 9.42 | 0.0023 | 0.004 | 0.004 | 0.02 | 0.8944 | 0.903 | 0.903 | 8.31 | 0.0041 | 0.251 | 0.251 | 4.46 | 0.0354 |
| | Season | 2 | 11.052 | 5.526 | 30.65 | 0.0001 | 7.145 | 3.573 | 28.84 | 0.0001 | 5.630 | 2.815 | 11.50 | 0.0001 | 44.135 | 22.068 | 203.18 | 0.0001 | 0.871 | 0.436 | 7.73 | 0.0005 |
| | Year | 7 | 8.880 | 1.269 | 7.04 | 0.0001 | 2.258 | 0.323 | 2.60 | 0.0123 | 34.957 | 4.994 | 20.54 | 0.0001 | 21.505 | 3.072 | 28.28 | 0.0001 | 4.116 | 0.588 | 10.45 | 0.0001 |
| | Net position | 1 | 20.923 | 20.923 | 116.04 | 0.0001 | 128.616 | 128.616 | 1038.22 | 0.0001 | 4.819 | 4.819 | 19.82 | 0.0001 | 0.598 | 0.598 | 5.51 | 0.0194 | 3.858 | 3.858 | 68.53 | 0.0001 |
| Season x Location | | 2 | 0.672 | 0.336 | 1.86 | 0.1561 | 0.046 | 0.023 | 0.19 | 0.8300 | 0.728 | 0.364 | 1.50 | 0.2250 | 1.013 | 0.507 | 4.66 | 0.0099 | 0.215 | 0.108 | 1.91 | 0.1490 |
| Year x Location | | 7 | 1.570 | 0.224 | 1.24 | 0.2765 | 1.071 | 0.153 | 1.23 | 0.2816 | 0.935 | 0.134 | 0.55 | 0.7982 | 2.270 | 0.324 | 2.99 | 0.0047 | 0.178 | 0.025 | 0.45 | 0.8690 |
| Location x Net position | | 1 | 0.842 | 0.842 | 4.67 | 0.0312 | 1.592 | 1.592 | 12.85 | 0.0004 | 0.262 | 0.262 | 1.08 | 0.3003 | 0.137 | 0.137 | 1.26 | 0.2618 | 0.099 | 0.099 | 1.75 | 0.1863 |
| Year x Season | | 14 | 12.483 | 0.892 | 4.94 | 0.0001 | 6.873 | 0.491 | 3.96 | 0.0001 | 6.233 | 0.445 | 1.83 | 0.0323 | 9.851 | 0.704 | 6.48 | 0.0001 | 1.851 | 0.132 | 2.35 | 0.0039 |
| Season x Net position | | 2 | 0.432 | 0.216 | 1.20 | 0.3030 | 0.311 | 0.156 | 1.25 | 0.2866 | 2.409 | 1.205 | 4.95 | 0.0075 | 0.411 | 0.206 | 1.89 | 0.1523 | 0.292 | 0.146 | 2.59 | 0.0759 |
| Year x Net position | | 7 | 5.978 | 0.854 | 4.74 | 0.0001 | 0.619 | 0.088 | 0.71 | 0.6622 | 2.842 | 0.406 | 1.67 | 0.1130 | 3.271 | 0.467 | 4.30 | 0.0002 | 1.332 | 0.190 | 3.38 | 0.0017 |
| Year x Season x Net position | | 14 | 5.331 | 0.381 | 2.11 | 0.0105 | 2.603 | 0.186 | 1.50 | 0.1069 | 3.892 | 0.278 | 1.14 | 0.3175 | 3.847 | 0.275 | 2.53 | 0.0017 | 1.150 | 0.082 | 1.46 | 0.1230 |
| Year x Location x Net position | | 7 | 1.367 | 0.195 | 1.08 | 0.3731 | 0.449 | 0.064 | 0.52 | 0.8222 | 0.849 | 0.120 | 0.53 | 0.8147 | 1.202 | 0.172 | 1.58 | 0.1382 | 0.187 | 0.027 | 0.47 | 0.8540 |
| Season x Location x Net position | | 2 | 1.080 | 0.540 | 2.99 | 0.0511 | 0.358 | 0.179 | 1.45 | 0.2367 | 1.154 | 0.577 | 2.37 | 0.0944 | 0.148 | 0.074 | 0.68 | 0.5064 | 0.357 | 0.179 | 3.17 | 0.0430 |
| Year x Season x Location | | 14 | 2.660 | 0.190 | 1.05 | 0.3986 | 1.728 | 0.123 | 1.00 | 0.4559 | 2.748 | 0.196 | 0.81 | 0.6614 | 3.570 | 0.255 | 2.35 | 0.0039 | 0.571 | 0.041 | 0.72 | 0.7500 |
| Year x Season x Location x Net position | | 14 | 2.414 | 0.172 | 0.96 | 0.4940 | 1.163 | 0.083 | 0.661 | 0.8106 | 1.765 | 0.126 | 0.51 | 0.9275 | 2.202 | 0.157 | 1.471 | 0.1185 | 0.860 | 0.061 | 1.09 | 0.3646 |
| Explained | | 95 | 80.161 | 0.844 | 4.67 | 0.0001 | 186.516 | 1.963 | 15.87 | 0.0001 | 82.805 | 0.872 | 3.53 | 0.0001 | 108.830 | 1.146 | 10.71 | 0.0001 | 18.928 | 0.199 | 3.55 | 0.0001 |
| Residual | | 410 | 74.038 | 0.181 | | | 51.363 | 0.125 | | | 101.331 | 0.247 | | | 43.850 | 0.107 | | | 23.009 | 0.056 | | |
| Total | | 505 | 154.199 | | | | 237.879 | | | | 184.136 | | | | 152.679 | | | | 41.937 | | | |

Table 3.2.2-3. Magnitudes of main effects from 4-factor ANOVA; 1974-1983 gillnet catches, Nanticoke, Long Point Bay, Lake Erie (see Table 3.2.2-3 for statistical significances).

| | | | SPECIES | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ALL FISH | | | | YELLOW PERCH | | | | ALEWIFE | | | | GIZZARD SHAD | | | | WHITE BASS | | | |
| Factor | | Number of Lifts | Total Catch | Mean Catch/ Lift | Least Square Means | Antilog Least Square Means | Total Catch | Mean Catch/ Lift | Least Square Means | Antilog Least Square Means | Total Catch | Mean Catch/ Lift | Least Square Means | Antilog Least Square Means | Total Catch | Mean Catch/ Lift | Least Square Means | Antilog Least Square Means | Total Catch | Mean Catch/ Lift | Least Square Means | Antilog Least Square Means |
| Year: | 1974 | 62 | 2,579 | 41.60 | 1.40 | 25.12 | 912 | 14.71 | 0.77 | 5.89 | 1,149 | 18.53 | 0.57 | 3.72 | 55 | 0.89 | 0.29 | 1.95 | 34 | 0.53 | 0.11 | 1.29 |
| | 1975 | 56 | 3,049 | 54.45 | 1.41 | 26.92 | 1,242 | 22.18 | 0.82 | 6.61 | 1,195 | 21.34 | 0.84 | 6.92 | 340 | 6.07 | 0.28 | 1.91 | 15 | 0.28 | 0.07 | 1.18 |
| | 1976 | 44 | 1,360 | 30.91 | 1.23 | 16.98 | 592 | 13.46 | 0.75 | 5.62 | 552 | 12.55 | 0.37 | 2.34 | 84 | 1.91 | 0.19 | 1.55 | 20 | 0.46 | 0.11 | 1.29 |
| | 1977 | 48 | 1,570 | 32.71 | 1.24 | 17.38 | 515 | 10.73 | 0.70 | 5.01 | 18 | 0.38 | 0.08 | 1.20 | 745 | 15.52 | 0.60 | 3.98 | 13 | 0.27 | 0.08 | 1.20 |
| | 1978 | 40 | 1,248 | 31.20 | 1.25 | 17.78 | 677 | 16.93 | 0.63 | 4.27 | 54 | 1.35 | 0.16 | 1.45 | 135 | 3.38 | 0.30 | 2.00 | 72 | 1.80 | 0.28 | 1.91 |
| | 1981 | 48 | 1,690 | 35.21 | 1.09 | 12.30 | 1,463 | 30.48 | 0.81 | 6.46 | 8 | 0.17 | 0.04 | 1.10 | 49 | 1.02 | 0.17 | 1.48 | 60 | 1.25 | 0.21 | 1.62 |
| | 1982 | 104 | 2,500 | 24.04 | 1.19 | 15.49 | 1,317 | 12.66 | 0.69 | 4.90 | 266 | 2.56 | 0.18 | 1.51 | 447 | 4.30 | 0.33 | 2.14 | 162 | 1.56 | 0.27 | 1.86 |
| | 1983 | 104 | 4,355 | 41.88 | 1.49 | 30.90 | 1,178 | 11.33 | 0.63 | 4.27 | 1,274 | 12.25 | 0.64 | 4.37 | 1,448 | 13.92 | 0.76 | 5.75 | 178 | 1.71 | 0.31 | 2.04 |
| Season: | Spring | 212 | 5,545 | 26.16 | 1.07 | 11.75 | 2,415 | 11.39 | 0.61 | 4.07 | 2,240 | 10.57 | 0.39 | 2.46 | 96 | 0.45 | 0.03 | 1.07 | 152 | 0.72 | 0.13 | 1.35 |
| | Summer | 158 | 7,215 | 45.67 | 1.37 | 23.44 | 3,749 | 23.73 | 0.90 | 7.94 | 1,945 | 12.31 | 0.50 | 3.16 | 729 | 4.61 | 0.21 | 1.62 | 190 | 1.20 | 0.16 | 1.45 |
| | Fall | 136 | 5,591 | 41.11 | 1.44 | 27.54 | 1,732 | 12.74 | 0.66 | 4.57 | 331 | 2.43 | 0.19 | 1.55 | 2,478 | 18.22 | 0.85 | 7.08 | 212 | 1.56 | 0.25 | 1.78 |
| Location: | Plume | 254 | 10,812 | 42.57 | 1.35 | 22.39 | 4,967 | 19.56 | 0.78 | 6.03 | 2,519 | 9.92 | 0.36 | 2.29 | 1,956 | 7.70 | 0.41 | 2.57 | 321 | 1.26 | 0.20 | 1.59 |
| | Control | 252 | 7,539 | 29.92 | 1.23 | 16.98 | 2,929 | 11.62 | 0.67 | 4.68 | 1,997 | 7.93 | 0.36 | 2.29 | 1,347 | 5.35 | 0.32 | 2.09 | 233 | 0.93 | 0.15 | 1.41 |
| Net Position: | Surface | 253 | 7,079 | 27.98 | 1.07 | 11.75 | 304 | 1.20 | 0.16 | 1.45 | 3,466 | 13.70 | 0.47 | 2.95 | 2,287 | 9.04 | 0.40 | 2.51 | 457 | 1.81 | 0.28 | 1.91 |
| | Bottom | 253 | 11,272 | 44.55 | 1.52 | 33.11 | 7,592 | 30.01 | 1.28 | 19.05 | 1,050 | 4.15 | 0.25 | 1.78 | 1,016 | 4.02 | 0.33 | [illegible].14 | 97 | 0.38 | 0.08 | 1.20 |

Table 3.2.2-4. Analyses of variance (3-factor model) of log transformed ($\log_{10} x + 1$) gillnet catches (surface and bottom catches analyzed separately), Nanticoke, Long Point Bay, Lake Erie (1974-1983).[1]

| | | SPECIES | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ALL FISH | | | | YELLOW PERCH | | | | ALEWIFE | | | | GIZZARD SHAD | | | | WHITE BASS | | | |
| Source of Variation | df | SS | MS | F | P | SS | MS | F | P | SS | MS | F | P | SS | MS | F | P | SS | MS | F | P |
| | | | | | | | | | | SURFACE | | | | | | | | | | | |
| Main Effects: Location | 1 | 0.029 | 0.029 | 0.12 | 0.7333 | 0.018 | 0.018 | 0.23 | 0.6295 | 0.056 | 0.056 | 0.17 | 0.6814 | 0.230 | 0.230 | 1.91 | 0.1688 | 0.374 | 0.374 | 4.55 | 0.0341 |
| Season | 2 | 5.453 | 2.727 | 11.01 | 0.0001 | 2.740 | 1.370 | 17.61 | 0.0001 | 6.124 | 3.062 | 9.31 | 0.0001 | 25.113 | 12.557 | 104.12 | 0.0001 | 0.808 | 0.404 | 4.91 | 0.0083 |
| Year | 7 | 13.363 | 1.909 | 7.71 | 0.0001 | 2.214 | 0.316 | 4.06 | 0.0004 | 22.606 | 3.229 | 9.82 | 0.0001 | 19.233 | 2.748 | 22.78 | 0.0001 | 5.035 | 0.719 | 8.74 | 0.0001 |
| Season x Location | 2 | 1.655 | 0.828 | 3.34 | 0.0373 | 0.176 | 0.088 | 1.13 | 0.3256 | 1.772 | 0.886 | 2.69 | 0.0701 | 0.410 | 0.205 | 1.70 | 0.1850 | 0.608 | 0.304 | 3.70 | 0.0265 |
| Year x Location | 7 | 2.195 | 0.314 | 1.27 | 0.2679 | 0.365 | 0.052 | 0.67 | 0.6989 | 1.166 | 0.167 | 0.51 | 0.8304 | 2.404 | 0.343 | 2.85 | 0.0075 | 0.326 | 0.047 | 0.57 | 0.7849 |
| Year x Season | 14 | 12.613 | 0.901 | 3.64 | 0.0001 | 2.080 | 0.149 | 1.91 | 0.0271 | 7.268 | 0.519 | 1.58 | 0.0876 | 8.610 | 0.615 | 5.10 | 0.0001 | 2.368 | 0.169 | 2.06 | 0.0156 |
| Year x Season x Location | 14 | 4.517 | 0.323 | 1.32 | 0.1983 | 2.170 | 0.155 | 1.99 | 0.0198 | 1.978 | 0.141 | 0.43 | 0.9646 | 3.418 | 0.244 | 2.02 | 0.0175 | 1.098 | 0.078 | 0.95 | 0.5030 |
| Explained | 47 | 42.948 | 0.914 | 3.69 | 0.0001 | 9.959 | 0.212 | 2.72 | 0.0001 | 48.588 | 1.034 | 3.14 | 0.0001 | 67.575 | 1.438 | 11.92 | 0.0001 | 10.725 | 0.228 | 2.77 | 0.0001 |
| Residual | 205 | 50.754 | 0.248 | | | 15.953 | 0.078 | | | 67.446 | 0.329 | | | 24.722 | 0.121 | | | 16.870 | 0.082 | | |
| Total | 252 | 93.702 | | | | 25.912 | | | | 116.034 | | | | 92.297 | | | | 27.595 | | | |
| | | | | | | | | | | BOTTOM | | | | | | | | | | | |
| Main Effects: Location | 1 | 2.320 | 2.320 | 20.43 | 0.0001 | 2.765 | 2.765 | 16.01 | 0.0001 | 0.108 | 0.108 | 0.65 | 0.4201 | 0.747 | 0.747 | 8.00 | 0.0051 | 0.009 | 0.009 | 0.31 | 0.5780 |
| Season | 2 | 6.080 | 3.040 | 26.77 | 0.0001 | 4.731 | 2.366 | 13.70 | 0.0001 | 1.862 | 0.931 | 5.63 | 0.0042 | 19.356 | 9.678 | 103.72 | 0.0001 | 0.333 | 0.167 | 5.56 | 0.0044 |
| Year | 7 | 1.493 | 0.213 | 1.88 | 0.0743 | 0.614 | 0.088 | 0.51 | 0.5296 | 15.190 | 2.170 | 13.13 | 0.0001 | 5.583 | 0.798 | 8.55 | 0.0001 | 0.443 | 0.063 | 2.11 | 0.0435 |
| Season x Location | 2 | 0.049 | 0.025 | 0.22 | 0.8062 | 0.248 | 0.124 | 0.72 | 0.4898 | 0.052 | 0.026 | 0.16 | 0.8536 | 0.662 | 0.331 | 3.55 | 0.0306 | 0.097 | 0.049 | 1.62 | 0.2000 |
| Year x Location | 7 | 0.579 | 0.083 | 0.73 | 0.6496 | 1.144 | 0.163 | 0.95 | 0.4729 | 0.868 | 0.124 | 0.75 | 0.6316 | 1.428 | 0.204 | 2.19 | 0.0366 | 0.059 | 0.008 | 0.28 | 0.9598 |
| Year x Season | 14 | 5.174 | 0.370 | 3.25 | 0.0001 | 7.330 | 0.524 | 3.03 | 0.0003 | 2.843 | 0.203 | 1.23 | 0.2561 | 5.097 | 0.364 | 3.90 | 0.0001 | 0.621 | 0.044 | 1.48 | 0.1203 |
| Year x Season x Location | 14 | 0.502 | 0.036 | 0.32 | 0.9916 | 0.720 | 0.051 | 0.30 | 0.9938 | 2.536 | 0.181 | 1.10 | 0.3631 | 2.354 | 0.168 | 1.80 | 0.0401 | 0.333 | 0.024 | 0.79 | 0.6744 |
| Explained | 47 | 16.578 | 0.353 | 3.11 | 0.0001 | 17.677 | 0.376 | 2.18 | 0.0001 | 24.593 | 0.523 | 3.17 | 0.0001 | 39.789 | 0.847 | 9.07 | 0.0001 | 2.333 | 0.050 | 1.66 | 0.009 |
| Residual | 205 | 23.284 | 0.114 | | | 35.409 | 0.173 | | | 33.885 | 0.165 | | | 19.128 | 0.093 | | | 6.139 | 0.030 | | |
| Total | 252 | 39.861 | | | | 53.086 | | | | 58.479 | | | | 58.917 | | | | 8.472 | | | |

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[1] See Table 3.2.2-5 for magnitude of main effects.

Table 3.2.2-5. Magnitudes of main effects from 3-factor ANOVA; 1974-1983 gillnet catches, Nanticoke, Long Point Bay, Lake Erie (see Table 3.2.2-4 for statistical significances).

| | | SPECIES | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ALL FISH | | | | YELLOW PERCH | | | | ALEWIFE | | | | GIZZARD SHAD | | | | WHITE BASS | | | |
| FACTOR | NUMBER OF LIFTS | Total Catch | Mean Catch/ Lift | Least Square Means | Antilog Least Square Means | Total Catch | Mean Catch/ Lift | Least Square Means | Antilog Least Square Means | Total Catch | Mean Catch/ Lift | Least Square Means | Antilog Least Square Means | Total Catch | Mean Catch/ Lift | Least Square Means | Antilog Least Square Means | Total Catch | Mean Catch/ Lift | Least Square Means | Antilog Least Square Means |
| | | | | | | | | | | SURFACE | | | | | | | | | | | |
| Year: 1974 | 31 | 1199 | 38.68 | 1.215 | 16.41 | 80 | 2.58 | 0.246 | 1.76 | 966 | 31.16 | 0.720 | 5.25 | 31 | 1.00 | 0.294 | 1.968 | 28 | 0.90 | 0.182 | 1.52 |
| 1975 | 28 | 1091 | 38.96 | 1.166 | 14.66 | 72 | 2.57 | 0.279 | 1.90 | 685 | 24.46 | 0.860 | 7.24 | 228 | 8.14 | 0.226 | 1.683 | 12 | 0.43 | 0.107 | 1.28 |
| 1976 | 22 | 569 | 25.86 | 0.991 | 9.80 | 22 | 1.00 | 0.157 | 1.44 | 493 | 22.41 | 0.581 | 3.81 | 14 | 0.64 | 0.125 | 1.33 | 14 | 0.64 | 0.157 | 1.44 |
| 1977 | 24 | 650 | 27.08 | 1.025 | 10.59 | 24 | 1.00 | 0.186 | 1.54 | 13 | 0.54 | 0.123 | 1.33 | 508 | 21.17 | 0.682 | 4.81 | 10 | 0.42 | 0.125 | 1.33 |
| 1978 | 20 | 361 | 18.05 | 1.048 | 11.17 | 0 | 0.00 | --- | 0.00 | 35 | 1.75 | 0.240 | 1.74 | 104 | 5.20 | 0.368 | 2.33 | 59 | 2.95 | 0.400 | 2.51 |
| 1981 | 24 | 146 | 6.08 | 0.648 | 4.45 | 51 | 2.13 | 0.275 | 1.88 | 8 | 0.33 | 0.083 | 1.21 | 21 | 0.88 | 0.153 | 1.42 | 49 | 2.04 | 0.308 | 2.03 |
| 1982 | 52 | 835 | 16.06 | 0.963 | 9.18 | 44 | 0.85 | 0.110 | 1.29 | 243 | 4.67 | 0.278 | 1.90 | 374 | 7.19 | 0.432 | 2.70 | 135 | 2.60 | 0.415 | 2.60 |
| 1983 | 52 | 2228 | 42.85 | 1.462 | 28.97 | 11 | 0.21 | 0.031 | 1.07 | 1023 | 19.67 | 0.868 | 7.38 | 1007 | 19.37 | 0.928 | 8.47 | 150 | 2.89 | 0.489 | 3.08 |
| Season: Spring | 106 | 2451 | 23.12 | 0.853 | 7.13 | 94 | 0.87 | 0.088 | 1.23 | 1980 | 18.68 | 0.595 | 3.94 | 94 | 0.89 | 0.066 | 1.16 | 123 | 1.16 | 0.193 | 1.56 |
| Summer | 79 | 2421 | 30.65 | 1.092 | 12.36 | 192 | 2.43 | 0.322 | 2.10 | 1315 | 16.65 | 0.612 | 4.09 | 541 | 6.85 | 0.208 | 1.61 | 178 | 2.25 | 0.277 | 1.89 |
| Fall | 68 | 2207 | 32.46 | 1.248 | 17.70 | 18 | 0.27 | 0.072 | 1.18 | 171 | 2.52 | 0.201 | 1.59 | 1652 | 24.29 | 0.929 | 8.49 | 156 | 2.29 | 0.349 | 2.23 |
| Location: Plume | 127 | 3855 | 30.35 | 1.077 | 11.94 | 153 | 1.21 | 0.151 | 1.42 | 1924 | 15.15 | 0.452 | 2.83 | 1240 | 9.76 | 0.435 | 2.72 | 264 | 2.08 | 0.316 | 2.07 |
| Control | 126 | 3224 | 25.59 | 1.053 | 11.30 | 151 | 1.20 | 0.170 | 1.48 | 1542 | 12.24 | 0.486 | 3.06 | 1047 | 8.31 | 0.367 | 2.33 | 193 | 1.53 | 0.229 | 1.69 |
| | | | | | | | | | | BOTTOM | | | | | | | | | | | |
| Year: 1974 | 31 | 1380 | 44.52 | 1.588 | 38.73 | 832 | 26.84 | 1.291 | 19.54 | 183 | 5.90 | 0.423 | 2.65 | 24 | 0.77 | 0.279 | 1.90 | 6 | 0.19 | 0.033 | 1.08 |
| 1975 | 28 | 1958 | 69.93 | 1.686 | 48.53 | 1170 | 41.79 | 1.345 | 22.13 | 510 | 18.21 | 0.820 | 2.27 | 112 | 4.00 | 0.338 | 2.18 | 3 | 0.11 | 0.034 | 1.08 |
| 1976 | 22 | 791 | 35.96 | 1.478 | 30.06 | 570 | 25.91 | 1.334 | 21.58 | 59 | 2.68 | 0.162 | 1.45 | 70 | 3.18 | 0.262 | 1.83 | 6 | 0.27 | 0.058 | 1.14 |
| 1977 | 24 | 920 | 38.33 | 1.464 | 29.11 | 491 | 20.46 | 1.208 | 16.14 | 5 | 0.21 | 0.042 | 1.10 | 237 | 9.88 | 0.518 | 3.30 | 3 | 0.13 | 0.026 | 1.06 |
| 1978 | 20 | 887 | 44.35 | 1.455 | 28.51 | 677 | 33.85 | 1.258 | 18.11 | 19 | 0.95 | 0.072 | 1.18 | 31 | 1.55 | 0.239 | 1.73 | 13 | 0.65 | 0.150 | 1.41 |
| 1981 | 24 | 1544 | 64.33 | 1.521 | 33.19 | 1412 | 58.83 | 1.353 | 22.54 | 0 | 0.00 | --- | 0.00 | 28 | 1.17 | 0.185 | 1.53 | 11 | 0.46 | 0.115 | 1.30 |
| 1982 | 52 | 1665 | 32.02 | 1.421 | 26.36 | 1273 | 24.48 | 1.270 | 18.62 | 23 | 0.44 | 0.086 | 1.22 | 73 | 1.40 | 0.219 | 1.66 | 27 | 0.52 | 0.122 | 1.32 |
| 1983 | 52 | 2127 | 40.90 | 1.525 | 33.50 | 1167 | 22.44 | 1.221 | 16.63 | 251 | 4.83 | 0.409 | 2.56 | 441 | 8.48 | 0.588 | 3.87 | 28 | 0.54 | 0.123 | 1.33 |
| Season: Spring | 106 | 3094 | 29.19 | 1.290 | 19.50 | 2321 | 21.90 | 1.137 | 13.71 | 260 | 2.45 | 0 192 | 1.56 | 2 | 0.02 | 0.003 | 1.01 | 29 | 0.27 | 0.067 | 1.17 |
| Summer | 79 | 4794 | 60.68 | 1.640 | 43.65 | 3557 | 45.03 | 1.478 | 30.06 | 630 | 7.98 | 0.385 | 2.43 | 188 | 2.38 | 0.207 | 1.61 | 12 | 0.15 | 0.038 | 1.09 |
| Fall | 68 | 3384 | 49.77 | 1.622 | 41.88 | 1714 | 25.21 | 1.240 | 17.38 | 160 | 2.35 | 0.178 | 1.51 | 826 | 12.15 | 0.776 | 5.97 | 56 | 0.82 | 0.143 | 1.39 |
| Location: Plume | 127 | 6957 | 54.78 | 1.625 | 42.17 | 4814 | 37.91 | 1.403 | 25.29 | 595 | 4.69 | 0.275 | 1.88 | 716 | 5.64 | 0.390 | 2.46 | 57 | 0.45 | 0.089 | 1.23 |
| Control | 126 | 4315 | 34.25 | 1.407 | 25.53 | 2778 | 22.05 | 1.167 | 3.21 | 455 | 3.61 | 0.229 | 1.69 | 300 | 2.38 | 0.267 | 1.85 | 40 | 0.32 | 0.076 | 1.19 |

Table 3.2.2-6. Analysis of variance of log transformed gillnet catches across periods (preoperational vs operational); Nanticoke, Long Point Bay, Lake Erie (1974-1983).[1]

| SOURCE OF VARIATION | df | SPECIES | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ALL FISH | | | | YELLOW PERCH | | | | ALEWIFE | | | | GIZZARD SHAD | | | | WHITE BASS | | | |
| | | SS | MS | F | P | SS | MS | F | P | SS | MS | F | P | SS | MS | F | P | SS | MS | F | P |
| Main Effects: Location | 1 | 1.749 | 1.749 | 7.33 | 0.0070 | 1.058 | 1.058 | 7.50 | 0.0064 | 0.015 | 0.015 | 0.05 | 0.8300 | 1.588 | 1.588 | 9.25 | 0.0025 | 0.188 | 0.188 | 3.17 | 0.0756 |
| Season | 2 | 11.315 | 5.658 | 23.72 | 0.0001 | 5.999 | 2.999 | 21.24 | 0.0001 | 6.646 | 3.323 | 10.14 | 0.0001 | 54.291 | 27.146 | 158.12 | 0.0001 | 1.351 | 0.676 | 11.43 | 0.0001 |
| Period | 1 | 0.167 | 0.167 | 0.70 | 0.4206 | 0.392 | 0.392 | 2.78 | 0.0963 | 1.070 | 1.070 | 3.26 | 0.0715 | 2.559 | 2.559 | 14.91 | 0.0001 | 2.662 | 2.662 | 45.03 | 0.0001 |
| Net Position | 1 | 20.233 | 20.233 | 84.83 | 0.0001 | 154.109 | 154.109 | 1093.55 | 0.0001 | 6.950 | 6.950 | 21.21 | 0.0001 | 1.409 | 1.409 | 8.21 | 0.0044 | 5.909 | 5.909 | 99.90 | 0.0001 |
| Season x Location | 2 | 0.769 | 0.385 | 1.61 | 0.2007 | 0.061 | 0.031 | 0.22 | 0.8063 | 0.947 | 0.474 | 1.44 | 0.2370 | 2.452 | 1.226 | 7.14 | 0.0009 | 0.224 | 0.112 | 1.90 | 0.1514 |
| Period x Location | 1 | 0.072 | 0.072 | 0.30 | 0.5820 | 0.002 | 0.002 | 0.01 | 0.9145 | 0.180 | 0.180 | 0.55 | 0.4594 | 0.089 | 0.089 | 0.52 | 0.4730 | 0.051 | 0.051 | 0.86 | 0.3545 |
| Location x Net Position | 1 | 0.687 | 0.687 | 2.88 | 0.0903 | 1.390 | 1.390 | 9.86 | 0.0018 | 0.302 | 0.302 | 0.92 | 0.3380 | 0.223 | 0.223 | 1.31 | 0.2546 | 0.099 | 0.099 | 1.68 | 0.1956 |
| Period x Season | 2 | 1.459 | 0.730 | 3.06 | 0.0479 | 0.312 | 0.156 | 1.11 | 0.3316 | 0.855 | 0.428 | 1.30 | 0.2725 | 2.037 | 1.019 | 5.93 | 0.0028 | 0.776 | 0.388 | 6.56 | 0.0015 |
| Season x Net Position | 2 | 0.439 | 0.220 | 0.92 | 0.3994 | 0.243 | 0.122 | 0.86 | 0.4237 | 3.967 | 1.984 | 6.05 | 0.0025 | 0.481 | 0.241 | 1.40 | 0.2471 | 0.459 | 0.230 | 3.88 | 0.0213 |
| Period x Net Position | 1 | 0.137 | 0.137 | 0.58 | 0.4482 | 0.066 | 0.066 | 0.47 | 0.4933 | 0.207 | 0.207 | 0.63 | 0.4271 | 1.400 | 1.400 | 8.30 | 0.0040 | 0.814 | 0.814 | 13.78 | 0.0002 |
| Period x Season x Net Position | 2 | 0.638 | 0.319 | 1.34 | 0.2638 | 0.300 | 0.150 | 1.06 | 0.3461 | 0.028 | 0.014 | 0.04 | 0.9581 | 0.085 | 0.043 | 0.25 | 0.7800 | 0.393 | 0.197 | 3.32 | 0.0368 |
| Period x Location x Net Position | 1 | 0.006 | 0.006 | 0.02 | 0.8792 | 0.111 | 0.111 | 0.79 | 0.3750 | 0.008 | 0.008 | 0.02 | 0.8790 | 0.155 | 0.155 | 0.90 | 0.3432 | 0.001 | 0.001 | 0.01 | 0.9306 |
| Season x Location x Net Position | 2 | 1.184 | 0.592 | 2.48 | 0.0846 | 0.392 | 0.196 | 1.39 | 0.2504 | 1.174 | 0.587 | 1.79 | 0.1680 | 0.165 | 0.083 | 0.48 | 0.6180 | 0.411 | 0.206 | 3.47 | 0.0318 |
| Period x Season x Location | 2 | 0.117 | 0.059 | 0.24 | 0.7834 | 0.202 | 0.101 | 0.72 | 0.4884 | 0.223 | 0.112 | 0.34 | 0.7119 | 0.113 | 0.057 | 0.33 | 0.7203 | 0.104 | 0.052 | 0.88 | 0.4155 |
| Period x Season x Location x Net Position | 2 | 0.143 | 0.072 | 0.30 | 0.7412 | 0.171 | 0.086 | 0.61 | 0.5454 | 0.134 | 0.067 | 0.20 | 0.8153 | 0.084 | 0.042 | 0.24 | 0.7832 | 0.015 | 0.008 | 0.13 | 0.8825 |
| Explained | 23 | 39.234 | 1.706 | 7.15 | 0.0001 | [illegible] | 7.188 | 52.40 | 0.0001 | 26.153 | 1.137 | 3.47 | 0.0001 | 69.929 | 3.040 | 17.71 | 0.0001 | 13.450 | 0.585 | 9.89 | 0.0001 |
| Residual | 482 | 114.965 | 0.239 | | | [illegible] | 0.141 | | | 157.962 | 0.328 | | | 82.750 | 0.172 | | | 28.487 | 0.059 | | |
| Total | 505 | 154.199 | | | | [illegible] | | | | 184.116 | | | | 152.679 | | | | 41.937 | | | |

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[1] See Table 3.2.2-7 for magnitude of main effects.

Table 3.2.2-7. Magnitudes of main effects from 4-factor ANOVA (preoperational vs operational); 1974-1983 gillnet catches, Nanticoke, Long Point Bay, Lake Erie (see table 3.2.2-7 for statistical significances).

| | | | SPECIES | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ALL FISH | | | | YELLOW PERCH | | | | ALEWIFE | | | | GIZZARD SHAD | | | | WHITE BASS | | | |
| | | Number of Lifts | Total Catch | Mean Catch/ Lift | Least Square Mean | Antilog Least Square Mean | Total Catch | Mean Catch Lift | Least Square Mean | Antilog Least Sqaure Mean | Total Catch | Mean Catch/ Lift | Least Square Mean | Antilog Least Sqaure Mean | Total Catch | Mean Catch/ Lift | Least Square Mean | Antilog Least Square Mean | Total Catch | Mean Catch/ Lift | Least Square Mean | Antilog Least Sqaure Mean |
| Period: | Preoperational | 250 | 9806 | 39.22 | 1.33 | 21.38 | 3938 | 15.75 | 0.75 | 5.62 | 2968 | 11.87 | 0.43 | 2.69 | 1359 | 5.44 | 0.32 | 2.09 | 154 | 0.62 | 0.13 | 1.35 |
| | Operational | 256 | 8545 | 33.38 | 1.29 | 19.50 | 3958 | 15.46 | 0.69 | 4.90 | 1548 | 6.05 | 0.34 | 2.19 | 1944 | 7.59 | 0.47 | 2.95 | 400 | 1.56 | 0.27 | 1.86 |
| Season: | Spring | 212 | 5545 | 26.16 | 1.11 | 12.88 | 2415 | 11.39 | 0.64 | 4.37 | 2240 | 10.57 | 0.42 | 2.63 | 96 | 0.45 | 0.06 | 1.15 | 152 | 0.72 | 0.14 | 1.38 |
| | Summer | 158 | 7215 | 45.67 | 1.39 | 24.55 | 3749 | 23.73 | 0.87 | 7.41 | 1945 | 12.31 | 0.52 | 3.31 | 729 | 4.61 | 0.27 | 1.86 | 190 | 1.20 | 0.18 | 1.51 |
| | Fall | 136 | 5591 | 41.11 | 1.44 | 27.54 | 1732 | 12.74 | 0.64 | 4.37 | 331 | 2.43 | 0.22 | 1.25 | 2478 | 18.22 | 0.87 | 7.41 | 212 | 1.56 | 0.27 | 1.86 |
| Location: | Plume | 254 | 10812 | 42.57 | 1.37 | 23.44 | 4967 | 19.56 | 0.76 | 5.75 | 2519 | 9.92 | 0.39 | 2.46 | 1956 | 7.70 | 0.45 | 2.82 | 321 | 1.26 | 0.22 | 1.66 |
| | Control | 252 | 7539 | 29.92 | 1.25 | 17.78 | 2929 | 11.62 | 0.67 | 4.68 | 1997 | 7.93 | 0.38 | 2.40 | 1347 | 5.35 | 0.34 | 2.19 | 233 | 0.93 | 0.18 | 1.51 |
| Net Position: | Surface | 253 | 7079 | 27.98 | 1.11 | 12.88 | 304 | 1.20 | 0.15 | 1.41 | 3466 | 13.70 | 0.51 | 3.24 | 2287 | 9.04 | 0.45 | 2.82 | 457 | 1.81 | 0.37 | 2.04 |
| | Bottom | 253 | 11272 | 44.55 | 1.52 | 33.11 | 7592 | 30.01 | 1.28 | 19.06 | 1050 | 4.15 | 0.27 | 1.86 | 1016 | 4.02 | 0.34 | 2.19 | 97 | 0.38 | 0.09 | 1.23 |

Table 3.2.2-8. Year class composition, mean fork length (mm) of yellow perch, white bass and smallmouth bass taken by experimental gillnets near Nanticoke, Long Point Bay, Lake Erie, 1981.

| | PLUME | | | | | | CONTROL | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year Class | 1981 | 1980 | 1979 | 1978 | 1977 | | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | |
| Age | 0 | 1 | 2 | 3 | 4 | N | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | N |
| YELLOW PERCH | | | | | | | | | | | | | | | |
| **% Composition** | | | | | | | | | | | | | | | |
| Males | | 1.3 | 24.5 | 10.0 | 2.9 | 213 | 1.2 | 22.1 | 12.2 | 3.1 | | | | | 124 |
| Females | | 3.6 | 48.9 | 7.8 | 0.9 | 337 | 3.1 | 46.7 | 9.7 | 1.6 | | | | 0.3 | 196 |
| Combined | | 4.4 | 79.0 | 13.8 | 2.8 | 733 | 4.6 | 71.5 | 19.6 | 4.1 | | | | 0.2 | 418 |
| **Length** | | | | | | | | | | | | | | | |
| Males | | 132.1 | 144.4 | 171.1 | 184.0 | 213 | 139.3 | 148.3 | 177.0 | 184.8 | | | | | 124 |
| Females | | 136.6 | 147.8 | 181.2 | 213.2 | 337 | 143.0 | 156.3 | 180.6 | 208.4 | | | | 195.0 | 196 |
| Combined | | 135.4 | 146.7 | 175.5 | 191.0 | 550 | 141.9 | 153.7 | 178.6 | 192.7 | | | | 195.0 | 320 |
| **Weight** | | | | | | | | | | | | | | | |
| Males | | 35.3 | 45.0 | 76.9 | 89.8 | 213 | 39.3 | 49.5 | 85.4 | 97.4 | | | | | 124 |
| Females | | 35.9 | 48.7 | 87.2 | 137.2 | 337 | 41.6 | 57.9 | 85.0 | 129.4 | | | | 117.0 | 196 |
| Combined | | 35.8 | 47.5 | 81.5 | 101.1 | 550 | 40.9 | 55.2 | 85.2 | 108.1 | | | | 117.0 | 320 |
| WHITE BASS | | | | | | | | | | | | | | | |
| **% Composition** | | | | | | | | | | | | | | | |
| Males | 3.7 | 48.1 | | | | 14 | 61.1 | | | | | | | | 11 |
| Females | | 40.7 | | 7.4 | | 13 | 27.8 | | 11.1 | | | | | | 7 |
| Combined | 3.7 | 88.9 | | 7.4 | | 28 | 88.9 | | 11.1 | | | | | | 21 |
| **Length** | | | | | | | | | | | | | | | |
| Males | 118.0 | 193.0 | | | | 14 | 198.3 | | | | | | | | 11 |
| Females | | 197.5 | | 313.0 | | 13 | 192.4 | | 313.5 | | | | | | 7 |
| Combined | 118.0 | 195.1 | | 313.0 | | 27 | 196.4 | | 313.5 | | | | | | 18 |
| **Weight** | | | | | | | | | | | | | | | |
| Males | 25.0 | 137.5 | | | | 14 | 147.4 | | | | | | | | 11 |
| Females | | 147.5 | | 560.5 | | 13 | 128.6 | | 636.0 | | | | | | 7 |
| Combined | 25.0 | 142.1 | | 560.5 | | 27 | 141.5 | | 636.0 | | | | | | 18 |
| SMALLMOUTH BASS | | | | | | | | | | | | | | | |
| **% Composition** | | | | | | | | | | | | | | | |
| Males | | | 33.3 | 66.7 | | 3 | 45.4 | 9.1 | 18.2 | | | | | | 8 |
| Females | | | | | | | 9.1 | 9.1 | 9.1 | | | | | | 3 |
| Combined | | | 33.3 | 66.7 | | 3 | 54.5 | 18.2 | 27.3 | | | | | | 11 |
| **Length** | | | | | | | | | | | | | | | |
| Males | | | 180.0 | 226.0 | | 3 | 183.4 | 235.0 | 253.0 | | | | | | 8 |
| Females | | | | | | | 138.0 | 177.0 | 226.0 | | | | | | 3 |
| Combined | | | 180.0 | 226.0 | | 3 | 175.8 | 206.0 | 244.0 | | | | | | 11 |
| **Weight** | | | | | | | | | | | | | | | |
| Males | | | 96.0 | 184.5 | | 3 | 105.8 | 233.0 | 275.0 | | | | | | 8 |
| Females | | | | | | | 36.0 | 96.0 | 163.0 | | | | | | 3 |
| Combined | | | 96.0 | 184.5 | | 3 | 94.2 | 164.5 | 237.7 | | | | | | 11 |

Table 3.2.2-9. Year class composition, mean fork length (mm) and weight (g) of yellow perch, white bass and smallmouth bass taken by experimental gillnets near Nanticoke, Long Point Bay, Lake Erie, 1982.

| | PLUME | | | | | | | | | CONTROL | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR CLASS | 1982 | 1981 | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | | 1982 | 1981 | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | |
| AGE | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | N | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | N |
| YELLOW PERCH | | | | | | | | | | | | | | | | | | | |
| % Composition | | | | | | | | | | | | | | | | | | | |
| Males | | 3.0 | 15.6 | 27.9 | 1.0 | 0.2 | | | 321 | | 1.3 | 9.6 | 16.6 | 0.5 | | | | | 108 |
| Females | | 5.5 | 25.9 | 20.5 | 0.1 | 0.2 | 0.1 | | 352 | | 4.1 | 23.6 | 42.0 | 1.5 | 0.5 | | | 0.3 | 278 |
| Combined | | 8.6 | 41.6 | 48.2 | 1.2 | 0.3 | 0.1 | | 678 | | 5.3 | 33.8 | 58.1 | 2.0 | 0.5 | | | 0.3 | 396 |
| Length | | | | | | | | | | | | | | | | | | | |
| Males | | 138.4 | 145.9 | 171.1 | 184.1 | 209.0 | | | 321 | | 134.0 | 151.5 | 175.0 | 172.5 | | | | | 108 |
| Females | | 139.6 | 154.2 | 179.4 | 201.0 | 275.0 | 318.0 | | 352 | | 140.4 | 157.8 | 183.90 | 203.3 | 261.5 | | | 341.0 | 278 |
| Combined | | 139.2 | 151.1 | 174.6 | 186.3 | 242.0 | 318.0 | | 673 | | 138.9 | 156.0 | 181.4 | 195.6 | 261.5 | | | 341.0 | 386 |
| Weight | | | | | | | | | | | | | | | | | | | |
| Males | | 37.7 | 42.6 | 73.7 | 86.7 | 134.0 | | | 321 | | 36.5 | 48.8 | 78.8 | 74.5 | | | | | 108 |
| Females | | 37.2 | 53.1 | 81.2 | 120.0 | 291.0 | 536.0 | | 352 | | 38.9 | 56.3 | 88.4 | 120.8 | 252.0 | | | 678.0 | 278 |
| Combined | | 37.4 | 49.2 | 76.9 | 90.9 | 212.5 | 536.0 | | 673 | | 38.4 | 54.2 | 85.7 | 109.3 | 252.0 | | | 678.0 | 386 |
| WHITE BASS | | | | | | | | | | | | | | | | | | | |
| % Composition | | | | | | | | | | | | | | | | | | | |
| Males | 4.6 | 24.4 | 15.1 | | 1.2 | | | | 39 | 1.6 | 30.2 | 14.2 | | | | | | | 29 |
| Females | | 31.4 | 20.9 | 1.2 | 1.2 | | | | 47 | | 30.2 | 23.8 | | | | | | | 34 |
| Combined | 4.7 | 55.8 | 36.0 | 1.2 | 2.3 | | | | 86 | 1.6 | 60.3 | 30.1 | | | | | | | 63 |
| Length | | | | | | | | | | | | | | | | | | | |
| Males | 125.0 | 146.9 | 227.2 | | 332.0 | | | | 39 | 121.0 | 142.8 | 228.9 | | | | | | | 29 |
| Females | | 157.7 | 228.6 | 302.0 | 311.0 | | | | 47 | | 147.3 | 231.9 | | | | | | | 34 |
| Combined | 125.0 | 153.0 | 228.0 | 302.0 | 321.5 | | | | 86 | 121.0 | 145.0 | 230.8 | | | | | | | 63 |
| Weight | | | | | | | | | | | | | | | | | | | |
| Males | 77.5 | 51.1 | 205.8 | | 719.0 | | | | 39 | 32.0 | 51.8 | 218.3 | | | | | | | 29 |
| Females | | 65.7 | 216.8 | 579.0 | 536.0 | | | | 47 | | 48.8 | 205.7 | | | | | | | 34 |
| Combined | 77.5 | 59.3 | 212.2 | 579.0 | 627.5 | | | | 86 | 32.0 | 50.3 | 210.5 | | | | | | | 63 |
| SMALLMOUTH BASS | | | | | | | | | | | | | | | | | | | |
| % Composition | | | | | | | | | | | | | | | | | | | |
| Males | | | 21.4 | | 7.2 | 7.1 | | | 4 | | 18.2 | 9.1 | 4.5 | | | | | | 7 |
| Females | | 7.2 | 35.7 | | 7.1 | 7.1 | 7.1 | 7.1 | 10 | | 18.2 | 45.5 | 4.5 | | | | | | 15 |
| Combined | | 7.2 | 57.1 | | 14.3 | 7.2 | 7.1 | 7.1 | 14 | | 36.4 | 54.5 | 9.1 | | | | | | 22 |
| Length | | | | | | | | | | | | | | | | | | | |
| Males | | | 223.3 | | 311.0 | | | | 4 | | 149.5 | 193.0 | 250.0 | | | | | | 7 |
| Females | | 139.0 | 228.8 | | 319.0 | 324.0 | 336.0 | 397.0 | 10 | | 152.0 | 218.6 | 237.0 | | | | | | 15 |
| Combined | | 139.0 | 226.8 | | 315.0 | 324.0 | 336.0 | 397.0 | 14 | | 150.8 | 214.3 | 243.5 | | | | | | 22 |
| Weight | | | | | | | | | | | | | | | | | | | |
| Males | | | 190.3 | | 544.0 | | | | 4 | | 53.8 | 121.0 | 256.0 | | | | | | 7 |
| Females | | 42.0 | 214.2 | | 639.0 | 643.0 | 633.0 | 1314.0 | 10 | | 57.8 | 181.6 | 222.0 | | | | | | 15 |
| Combined | | 42.0 | 205.3 | | 591.5 | 643.0 | 633.0 | 1314.0 | 14 | | 55.8 | 171.5 | 239.0 | | | | | | 22 |

Table 3.2.2-10. Year class composition, mean fork length (mm) and weight (g) of yellow perch, white bass and smallmouth bass taken by experimental gillnet near Nanticoke, Long Point Bay, Lake Erie, 1983.

| | PLUME | | | | | | | CONTROL | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR CLASS | 1983 | 1982 | 1981 | 1980 | 1979 | 1978 | | 1982 | 1981 | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | |
| AGE | 0 | 1 | 2 | 3 | 4 | 5 | N | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | N |
| | | | | | | | | YELLOW PERCH | | | | | | | | | | |
| % Composition | | | | | | | | | | | | | | | | | | |
| Males | | 1.5 | 24.6 | 5.3 | 1.8 | 0.2 | 206 | 0.9 | 22.6 | 5.1 | 1.4 | | 0.2 | | | | | 130 |
| Females | | 2.7 | 56.7 | 6.6 | 0.6 | | 413 | 1.7 | 59.2 | 7.5 | 1.2 | | | | | | 0.2 | 299 |
| Combined | | 4.2 | 81.4 | 11.8 | 2.4 | 0.2 | 636 | 2.6 | 81.7 | 12.8 | 2.6 | | 0.2 | | | | 0.2 | 431 |
| Length | | | | | | | | | | | | | | | | | | |
| Males | | 134.7 | 142.8 | 171.1 | 177.9 | 193.0 | 206 | 137.5 | 148.7 | 174.4 | 190.0 | | 265.0 | | | | | 130 |
| Females | | 137.1 | 143.9 | 172.1 | 215.0 | | 413 | 146.7 | 155.7 | 180.5 | 193.0 | | | | | | 333.0 | 299 |
| Combined | | 136.2 | 143.6 | 171.7 | 187.8 | 193.0 | 619 | 143.4 | 153.7 | 178.0 | 191.4 | | 265.0 | | | | 333.0 | 429 |
| Weight | | | | | | | | | | | | | | | | | | |
| Males | | 34.9 | 40.9 | 72.9 | 79.9 | 88.0 | 206 | 37.3 | 46.6 | 74.9 | 99.2 | | 262.0 | | | | | 130 |
| Females | | 35.6 | 43.3 | 71.9 | 146.3 | | 413 | 40.9 | 54.3 | 85.6 | 96.4 | | | | | | 611.0 | 299 |
| Combined | | 35.3 | 42.5 | 72.4 | 97.6 | 88.0 | 619 | 39.5 | 52.2 | 81.2 | 97.9 | | 262.0 | | | | 611.0 | 429 |
| | | | | | | | | WHITE BASS | | | | | | | | | | |
| % Composition | | | | | | | | | | | | | | | | | | |
| Males | 3.2 | 13.8 | 13.8 | 5.3 | | | 34 | 3.7 | 29.6 | 4.9 | | | | | | | | 31 |
| Females | 6.4 | 26.6 | 23.4 | 6.4 | | 1.1 | 60 | 16.1 | 38.3 | 7.4 | | | | | | | | 50 |
| Combined | 9.6 | 40.4 | 37.2 | 11.7 | | 1.1 | 94 | 19.8 | 67.9 | 12.3 | | | | | | | | 81 |
| Length | | | | | | | | | | | | | | | | | | |
| Males | 171.7 | 200.0 | 231.5 | 272.4 | | | 34 | 185.3 | 223.9 | 275.5 | | | | | | | | 31 |
| Females | 175.3 | 192.0 | 229.1 | 299.2 | | 342.0 | 60 | 180.9 | 219.2 | 288.7 | | | | | | | | 50 |
| Combined | 174.1 | 194.7 | 230.0 | 287.0 | | 342.0 | 94 | 181.8 | 221.2 | 283.4 | | | | | | | | 81 |
| Weight | | | | | | | | | | | | | | | | | | |
| Males | 78.0 | 122.8 | 210.8 | 382.2 | | | 34 | 95.0 | 187.9 | 380.0 | | | | | | | | 31 |
| Females | 81.2 | 110.5 | 199.8 | 520.3 | | 803.0 | 60 | 97.5 | 171.6 | 459.9 | | | | | | | | 50 |
| Combined | 80.1 | 114.7 | 203.9 | 457.5 | | 803.0 | 94 | 97.0 | 178.7 | 427.4 | | | | | | | | 81 |
| | | | | | | | | SMALLMOUTH BASS | | | | | | | | | | |
| % Composition | | | | | | | | | | | | | | | | | | |
| Males | | | | | | | | | 29.7 | 11.1 | | 3.7 | | | | | | 12 |
| Females | | 33.3 | 66.7 | | | | 3 | 3.7 | 22.2 | 22.2 | 3.7 | | 3.7 | | | | | 15 |
| Combined | | 33.3 | 66.7 | | | | 3 | 3.7 | 51.9 | 33.3 | 3.7 | 3.7 | 3.7 | | | | | 27 |
| Length | | | | | | | | | | | | | | | | | | |
| Males | | | | | | | | | 196.3 | 246.3 | | | | | | | | 12 |
| Females | | 147.0 | 220.5 | | | | 3 | 176.0 | 193.2 | 254.2 | 301.0 | 335.0 | 320.0 | | | | | 15 |
| Combined | | 147.0 | 220.5 | | | | 3 | 176.0 | 194.9 | 251.6 | 301.0 | 335.0 | 320.0 | | | | | 27 |
| Weight | | | | | | | | | | | | | | | | | | |
| Males | | | | | | | | | 114.0 | 238.3 | | | | | | | | 12 |
| Females | | 43.0 | 165.5 | | | | 3 | 78.0 | 104.2 | 253.0 | 466.0 | 653.0 | 559.0 | | | | | 15 |
| Combined | | 43.0 | 165.5 | | | | 3 | 78.0 | 109.8 | 248.1 | 466.0 | 653.0 | 559.0 | | | | | 27 |

Table 3.2.2-11. Seasonal year class composition, mean fork length (mm) and weight (g) of yellow perch taken by experimental gillnets near Nanticoke, Long Point Bay, Lake Erie, 1981.

| | | PLUME | | | | | CONTROL | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | YEAR CLASS | 1980 | 1979 | 1978 | 1977 | | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | |
| SEASON | AGE | 1 | 2 | 3 | 4 | N | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | N |
| Spring | % Composition | | | | | | | | | | | | | | |
| | Males | | 20.8 | 6.1 | 4.6 | 41 | | 21.9 | | | | | | | 7 |
| | Females | | 63.1 | 4.6 | 0.8 | 89 | | 46.9 | 21.9 | 6.2 | | | | 3.1 | 25 |
| | Combined | | 83.2 | 11.5 | 5.3 | 131 | | 68.8 | 21.9 | 6.2 | | | | 3.1 | 32 |
| | Length | | | | | | | | | | | | | | |
| | Males | | 136.4 | 163.1 | 183.5 | 41 | | 138.0 | | | | | | | 7 |
| | Females | | 138.2 | 179.2 | 231.0 | 89 | | 135.3 | 174.1 | 193.5 | | | | 195.0 | 25 |
| | Combined | | 137.8 | 170.0 | 190.3 | 130 | | 136.2 | 174.1 | 193.5 | | | | 195.0 | 32 |
| | Weight | | | | | | | | | | | | | | |
| | Males | | 32.7 | 58.3 | 84.3 | 41 | | 35.4 | | | | | | | 7 |
| | Females | | 34.6 | 71.0 | 171.0 | 89 | | 34.0 | 67.6 | 94.5 | | | | 117.0 | 25 |
| | Combined | | 34.1 | 63.7 | 96.7 | 130 | | 34.5 | 67.6 | 94.5 | | | | 117.0 | 32 |
| Summer | % Composition | | | | | | | | | | | | | | |
| | Males | 0.9 | 24.0 | 13.3 | 2.7 | 138 | 0.9 | 23.9 | 14.7 | 4.1 | | | | | 95 |
| | Females | 2.4 | 45.4 | 10.4 | 0.9 | 199 | 0.5 | 47.2 | 7.8 | 0.9 | | | | | 123 |
| | Combined | 3.1 | 78.8 | 15.8 | 2.3 | 518 | 2.2 | 74.2 | 19.4 | 4.2 | | | | | 314 |
| | Length | | | | | | | | | | | | | | |
| | Males | 129.7 | 143.6 | 172.0 | 182.9 | 138 | 139.0 | 147.1 | 174.0 | 179.7 | | | | | 95 |
| | Females | 136.1 | 149.1 | 180.8 | 201.3 | 199 | 143.0 | 155.4 | 176.8 | 225.5 | | | | | 123 |
| | Combined | 134.4 | 147.2 | 175.9 | 187.5 | 337 | 140.3 | 152.6 | 175.0 | 188.0 | | | | | 218 |
| | Weight | | | | | | | | | | | | | | |
| | Males | 36.7 | 46.3 | 79.4 | 91.0 | 138 | 40.0 | 48.6 | 80.5 | 87.4 | | | | | 123 |
| | Females | 40.0 | 52.1 | 88.4 | 111.3 | 199 | 50.0 | 57.3 | 81.4 | 176.0 | | | | | 95 |
| | Combined | 38.8 | 50.3 | 83.4 | 96.1 | 337 | 43.3 | 54.4 | 80.8 | 103.5 | | | | | 218 |
| Fall | % Composition | | | | | | | | | | | | | | |
| | Males | 4.8 | 32.5 | 2.4 | 1.2 | 34 | 2.9 | 17.1 | 10.0 | 1.4 | | | | | 22 |
| | Females | 14.5 | 41.0 | 2.4 | 1.2 | 49 | 12.9 | 45.7 | 8.6 | 1.4 | | | | | 48 |
| | Combined | 19.0 | 73.8 | 4.8 | 2.4 | 84 | 16.9 | 62.0 | 18.3 | 2.8 | | | | | 71 |
| | Length | | | | | | | | | | | | | | |
| | Males | 134.0 | 154.9 | 182.0 | 197.0 | 34 | 139.5 | 159.8 | 190.7 | 231.0 | | | | | 22 |
| | Females | 136.8 | 165.5 | 194.5 | 231.0 | 49 | 143.0 | 169.1 | 199.2 | 204.0 | | | | | 48 |
| | Combined | 136.1 | 160.8 | 188.3 | 214.0 | 83 | 142.4 | 166.5 | 194.6 | 217.5 | | | | | 70 |
| | Weight | | | | | | | | | | | | | | |
| | Males | 34.3 | 54.3 | 97.5 | 112.0 | 34 | 38.5 | 61.6 | 107.7 | 187.0 | | | | | 22 |
| | Females | 34.3 | 68.9 | 114.0 | 181.0 | 49 | 40.7 | 71.1 | 115.8 | 106.0 | | | | | 48 |
| | Combined | 34.3 | 62.4 | 105.8 | 146.5 | 83 | 40.3 | 68.5 | 111.5 | 146.5 | | | | | 70 |

Table 3.2.2-12. Seasonal year class composition, mean fork length (mm) and weight (g) of yellow perch taken by experimental gillnets near Nanticoke, Long Point Bay, Lake Erie, 1982.

| | | PLUME | | | | | | | CONTROL | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | YEAR CLASS | 1981 | 1980 | 1979 | 1978 | 1977 | 1976 | | 1981 | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | |
| SEASON | AGE | 1 | 2 | 3 | 4 | 5 | 6 | N | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | N |
| Spring | % Composition | | | | | | | | | | | | | | | | |
| | Males | | 22.2 | 20.8 | 1.4 | | | 96 | | 9.2 | 16.3 | 1.0 | | | | | 26 |
| | Females | | 27.3 | 27.8 | | | 0.5 | 120 | | 22.5 | 48.0 | | 2.0 | | | 1.0 | 72 |
| | Combined | | 49.5 | 48.6 | 1.4 | | 0.5 | 216 | | 31.6 | 64.3 | 1.0 | 2.1 | | | 1.0 | 98 |
| | Length | | | | | | | | | | | | | | | | |
| | Males | | 144.1 | 166.1 | 187.0 | | | 96 | | 148.6 | 167.3 | 178.0 | | | | | 26 |
| | Females | | 147.2 | 177.4 | | | 318.0 | 120 | | 146.6 | 179.3 | | 261.5 | | | 341.0 | 72 |
| | Combined | | 145.8 | 172.6 | 187.0 | | 318.0 | 216 | | 147.2 | 176.2 | 178.0 | 261.5 | | | 341.0 | 98 |
| | Weight | | | | | | | | | | | | | | | | |
| | Males | | 37.4 | 60.0 | 79.3 | | | 96 | | 38.1 | 61.6 | 75.0 | | | | | 26 |
| | Females | | 41.4 | 72.4 | | | 536.0 | 120 | | 39.8 | 78.2 | | 252.0 | | | 678.0 | 72 |
| | Combined | | 39.6 | 67.1 | 79.3 | | 536.0 | 216 | | 39.3 | 74.0 | 75.0 | 252.0 | | | 678.0 | 98 |
| Summer | % Composition | | | | | | | | | | | | | | | | |
| | Males | 1.0 | 14.3 | 35.4 | 1.4 | 0.3 | | 154 | 0.5 | 8.3 | 17.8 | 0.5 | | | | | 49 |
| | Females | 2.7 | 23.5 | 21.1 | 0.3 | | | 140 | 1.7 | 22.8 | 46.7 | 1.7 | | | | | 131 |
| | Combined | 3.7 | 38.3 | 56.0 | 1.7 | 0.3 | | 298 | 2.1 | 32.6 | 63.2 | 2.1 | | | | | 190 |
| | Length | | | | | | | | | | | | | | | | |
| | Males | 135.3 | 147.9 | 170.4 | 182.0 | 209.0 | | 154 | 132.0 | 143.1 | 175.6 | 167.0 | | | | | 49 |
| | Females | 131.5 | 152.2 | 177.1 | 201.0 | | | 140 | 134.0 | 155.0 | 181.8 | 195.7 | | | | | 131 |
| | Combined | 132.5 | 150.6 | 172.9 | 185.8 | 209.0 | | 294 | 133.5 | 151.8 | 180.0 | 188.5 | | | | | 180 |
| | Weight | | | | | | | | | | | | | | | | |
| | Males | 36.7 | 47.4 | 75.6 | 92.3 | 134.0 | | 154 | | 41.2 | 81.3 | 74.0 | | | | | 49 |
| | Females | 35.4 | 53.8 | 83.1 | 120.0 | | | 140 | 32.0 | 54.3 | 85.4 | 104.7 | | | | | 131 |
| | Combined | 35.7 | 51.4 | 78.4 | 97.8 | 134.0 | | 294 | 32.0 | 51.1 | 84.2 | 97.0 | | | | | 180 |
| Fall | % Composition | | | | | | | | | | | | | | | | |
| | Males | 10.5 | 9.2 | 23.9 | | | | 71 | 3.7 | 12.1 | 14.8 | | | | | | 33 |
| | Females | 17.8 | 28.2 | 9.8 | | 0.6 | | 92 | 12.0 | 25.9 | 28.7 | 2.8 | | | | | 75 |
| | Combined | 28.7 | 37.2 | 33.5 | | 0.6 | | 164 | 15.7 | 38.0 | 43.5 | 2.8 | | | | | 108 |
| | Length | | | | | | | | | | | | | | | | |
| | Males | 138.9 | 146.2 | 178.8 | | | | 71 | 134.5 | 163.4 | 181.8 | | | | | | 33 |
| | Females | 141.9 | 166.3 | 195.6 | | 275.0 | | 92 | 141.9 | 170.7 | 196.9 | 211.0 | | | | | 75 |
| | Combined | 140.8 | 161.4 | 183.7 | | 275.0 | | 163 | 140.2 | 168.4 | 191.8 | 211.0 | | | | | 108 |
| | Weight | | | | | | | | | | | | | | | | |
| | Males | 37.8 | 45.9 | 84.6 | | | | 71 | 36.5 | 63.9 | 91.2 | | | | | | 33 |
| | Females | 37.7 | 67.2 | 106.5 | | 291.0 | | 92 | 40.5 | 72.1 | 111.9 | 137.0 | | | | | 75 |
| | Combined | 37.7 | 62.0 | 90.9 | | 291.0 | | 163 | 39.5 | 69.5 | 104.9 | 137.0 | | | | | 108 |

Table 3.2.2-13. Seasonal year class composition, mean fork length (mm) and weight (g) of yellow perch taken by experimental gillnets near Nanticoke, Long Point Bay, Lake Erie, 1983.

| | | PLUME | | | | | | CONTROL | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | YEAR CLASS | 1982 | 1981 | 1980 | 1979 | 1978 | | 1982 | 1981 | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | |
| SEASON | AGE | 1 | 2 | 3 | 4 | 5 | N | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | N |
| Spring | % Composition | | | | | | | | | | | | | | | | | |
| | Males | | 11.8 | 2.7 | 1.4 | 0.5 | 36 | | 22.8 | 5.1 | | | | | | | | 44 |
| | Females | | 71.0 | 11.3 | 1.3 | | 185 | | 62.0 | 7.0 | 2.5 | | | | | | 0.6 | 114 |
| | Combined | | 82.8 | 14.0 | 2.7 | 0.5 | 221 | | 84.8 | 12.1 | 2.5 | | | | | | 0.6 | 158 |
| | Length | | | | | | | | | | | | | | | | | |
| | Males | | 141.8 | 157.7 | 174.7 | 193.0 | 36 | | 140.4 | 170.4 | | | | | | | | 44 |
| | Females | | 138.0 | 168.4 | 203.7 | | 185 | | 140.1 | 170.5 | 190.5 | | | | | | 333.0 | 114 |
| | Combined | | 138.5 | 166.3 | 189.2 | 193.0 | 221 | | 140.2 | 170.4 | 190.5 | | | | | | 333.0 | 158 |
| | Weight | | | | | | | | | | | | | | | | | |
| | Males | | 38.4 | 53.8 | 74.3 | 88.0 | 36 | | 36.8 | 67.6 | | | | | | | | 44 |
| | Females | | 38.2 | 67.4 | 114.7 | | 185 | | 38.8 | 68.9 | 91.0 | | | | | | 611.0 | 114 |
| | Combined | | 38.2 | 64.8 | 94.5 | 88.0 | 221 | | 38.2 | 68.4 | 91.0 | | | | | | 611.0 | 158 |
| Summer | % Composition | | | | | | | | | | | | | | | | | |
| | Males | 0.7 | 31.1 | 7.8 | 2.6 | | 114 | | 22.5 | 6.9 | 2.9 | | | | | | | 33 |
| | Females | 1.1 | 51.9 | 4.8 | | | 156 | | 50.0 | 16.7 | 1.0 | | | | | | | 69 |
| | Combined | 2.1 | 83.3 | 12.2 | 2.4 | | 287 | | 72.1 | 24.0 | 3.9 | | | | | | | 104 |
| | Length | | | | | | | | | | | | | | | | | |
| | Males | 136.5 | 141.4 | 172.2 | 178.0 | | 114 | | 142.1 | 178.6 | 187.0 | | | | | | | 33 |
| | Females | 134.3 | 143.0 | 176.7 | | | 156 | | 154.1 | 181.5 | 203.0 | | | | | | | 69 |
| | Combined | 135.2 | 142.4 | 173.9 | 178.0 | | 270 | | 150.4 | 180.7 | 191.0 | | | | | | | 102 |
| | Weight | | | | | | | | | | | | | | | | | |
| | Males | 37.5 | 39.4 | 74.2 | 80.6 | | 114 | | 40.0 | 82.4 | 90.0 | | | | | | | 33 |
| | Females | 33.7 | 41.4 | 77.7 | | | 156 | | 52.1 | 88.1 | 118.0 | | | | | | | 69 |
| | Combined | 35.2 | 40.7 | 75.5 | 80.6 | | 270 | | 48.4 | 86.4 | 97.0 | | | | | | | 102 |
| Fall | % Composition | | | | | | | | | | | | | | | | | |
| | Males | 5.5 | 32.8 | 4.7 | 0.8 | | 56 | 2.4 | 22.5 | 4.1 | 1.8 | 0.6 | | | | | | 53 |
| | Females | 10.9 | 42.2 | 2.3 | 0.8 | | 72 | 4.1 | 62.1 | 2.4 | | | | | | | | 116 |
| | Combined | 16.4 | 75.0 | 7.0 | 1.6 | | 128 | 6.5 | 84.6 | 6.5 | 1.8 | 0.6 | | | | | | 169 |
| | Length | | | | | | | | | | | | | | | | | |
| | Males | 134.0 | 146.3 | 180.3 | 187.0 | | 56 | 137.5 | 160.4 | 174.7 | 193.0 | 265.0 | | | | | | 53 |
| | Females | 137.6 | 163.5 | 184.0 | 249.0 | | 72 | 146.7 | 170.9 | 203.8 | | | | | | | | 116 |
| | Combined | 136.5 | 156.0 | 181.6 | 218.0 | | 128 | 143.4 | 168.1 | 185.3 | 193.0 | 265.0 | | | | | | 169 |
| | Weight | | | | | | | | | | | | | | | | | |
| | Males | 34.1 | 45.4 | 87.3 | 92.0 | | 56 | 37.3 | 60.0 | 75.6 | 108.3 | 262.0 | | | | | | 53 |
| | Females | 36.0 | 62.7 | 84.7 | 241.0 | | 72 | 40.9 | 69.8 | 121.0 | | | | | | | | 116 |
| | Combined | 35.4 | 55.1 | 86.4 | 166.5 | | 128 | 39.5 | 67.2 | 92.1 | 108.3 | 262.0 | | | | | | 169 |

Table 3.2.2-14. Seasonal mean lift-day temperatures (°C) at Plume and Control gillnet locations, Nanticoke, Long Point Bay, Lake Erie (1981-1983).

| LOCATION OF TEMPERATURE READING | MEAN TEMPERATURE (°C) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1981 | | 1982 | | 1983 | | Combined | |
| | Plume | Control | Plume | Control | Plume | Control | Plume | Control |
| | | | | SPRING | | | | |
| Bottom | 10.8 | 10.6 | 10.6 | 10.5 | 10.0 | 10.5 | 10.4 | 10.5 |
| Mid-Depth | 12.0 | 11.5 | 13.1 | 12.3 | 11.9 | 11.2 | 12.4 | 11.7 |
| Surface | 12.5 | 11.9 | 14.6 | 13.8 | 13.3 | 12.1 | 13.7 | 12.8 |
| | | | | SUMMER | | | | |
| Bottom | 19.3 | 19.6 | 16.4 | 17.5 | 18.3 | 19.2 | 17.7 | 18.6 |
| Mid-Depth | 19.9 | 20.0 | 19.3 | 18.5 | 19.7 | 20.1 | 19.6 | 19.4 |
| Surface | 21.6 | 20.6 | 20.1 | 19.4 | 23.4 | 21.4 | 21.7 | 20.5 |
| | | | | FALL | | | | |
| Bottom | 13.8 | 14.0 | 15.3 | 15.5 | 17.3 | 17.6 | 15.8 | 16.0 |
| Mid-Depth | 14.8 | 14.5 | 16.2 | 16.2 | 18.0 | 18.2 | 16.7 | 16.6 |
| Surface | 17.1 | 15.5 | 17.5 | 16.1 | 20.9 | 19.4 | 18.8 | 17.5 |

Table 3.2.2-15. Correlations of mean temperatures and secchi disk transparencies with mean catch ($\log_{10} x + 1$) per lift of selected fish species in surface and bottom gillnet catches at Nanticoke, Long Point Bay, Lake Erie (1974-1983). Locations combined.

| | | SURFACE NETS | | | | | | BOTTOM NETS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | VARIABLE | Yellow Perch | White Bass | Sm. Bass | Fw. Drum | Alewife | Gizzard Shad | Yellow Perch | White Bass | Sm. Bass | Fw. Drum | Alewife | Gizzard Shad |
| | | | | | | | SPRING | | | | | | |
| Temp. | Bottom | -.13 | .18 | | -.20 | .01 | -.05 | -.01 | $.30^c$ | $-.30^c$ | .04 | $.30^c$ | .13 |
| | Mid-Depth | -.11 | .14 | | $-.27^d$ | -.15 | -.23 | -.03 | $.33^c$ | $-.34^c$ | -.12 | .16 | .09 |
| | Surface | -.12 | .12 | | $-.30^c$ | -.19 | $-.31^c$ | -.08 | $.38^b$ | $-.31^c$ | -.21 | .17 | .07 |
| | Secchi | $-.38^c$ | $-.35^c$ | | $-.44^b$ | $-.37^c$ | -.15 | -.10 | .14 | $-.36^c$ | $-.44^b$ | .10 | -.03 |
| | | | | | | | SUMMER | | | | | | |
| Temp. | Bottom | $.28^d$ | -.12 | | | $-.61^a$ | $.37^c$ | .14 | -.17 | $.30^c$ | .26 | -.05 | $.66^a$ |
| | Mid-Depth | .26 | -.08 | | | $-.56^a$ | $.34^c$ | .19 | -.22 | .17 | .25 | -.06 | $.68^a$ |
| | Surface | .16 | -.10 | | | $-.48^b$ | $.39^c$ | .15 | -.09 | .05 | $.32^c$ | .15 | $.68^a$ |
| | Secchi | $-.27^d$ | $-.33^c$ | | | .16 | -.05 | -.13 | $-.41^b$ | $-.41^b$ | .07 | .15 | $-.27^d$ |
| | | | | | | | FALL | | | | | | |
| Temp. | Bottom | $-.30^c$ | $.27^d$ | .16 | .08 | .21 | $.66^a$ | $.64^a$ | -.06 | .21 | $.27^d$ | $.41^b$ | $.63^a$ |
| | Mid-Depth | $-.27^d$ | $.28^d$ | .21 | .14 | .20 | $.66^a$ | $.66^a$ | -.10 | .21 | $.31^c$ | $.37^c$ | $.62^a$ |
| | Surface | -.18 | $.37^c$ | .23 | .12 | .20 | $.63^a$ | $.62^a$ | -.06 | .12 | .21 | $.36^c$ | $.68^a$ |
| | Secchi | -.16 | $-.39^c$ | .04 | .09 | $-.52^a$ | .02 | .16 | -.14 | .07 | .01 | $-.59^a$ | -.25 |

[a] significant at $P = 0.001$ [b] significant at $P < 0.01$ [c] significant at $P < 0.05$ [d] significant at $P < 0.1$

Table 3.2.2-16. Correlations of mean temperatures with mean catch ($\log_{10} x + 1$) per lift of yellow perch, alewife and gizzard shad in gillnet catches at the plume and control locations, Nanticoke, Long Point Bay, Lake Erie (1974-1983).

| DEPTH OF TEMPERATURE READING | PLUME | | | | | | CONTROL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SURFACE NETS | | | BOTTOM NETS | | | SURFACE NETS | | | BOTTOM NETS | | |
| | Yellow Perch | Alewife | Gizzard Shad | Yellow Perch | Alewife | Gizzard Shad | Yellow Perch | Alewife | Gizzard Shad | Yellow Perch | Alewife | Gizzard Shad |
| SPRING | | | | | | | | | | | | |
| Bottom | -.07 | -.03 | -.24 | .08 | .13 | --- | -.18 | .06 | .12 | -.07 | .41$^c$ | .18 |
| Mid-Depth | .05 | -.21 | -.41$^c$ | -.06 | -.05 | --- | -.24 | -.12 | -.07 | -.16 | .34$^d$ | .16 |
| Surface | .05 | -.24 | -.43$^c$ | -.09 | -.11 | --- | -.26 | -.16 | -.21 | -.26 | .41$^c$ | .14 |
| SUMMER | | | | | | | | | | | | |
| Bottom | .30 | -.74$^a$ | .33 | .13 | -.01 | .69$^a$ | .26 | -.55$^b$ | .41$^d$ | .25 | -.07 | .66$^a$ |
| Mid-Depth | .29 | -.63$^a$ | .28 | .12 | -.07 | .68$^a$ | .21 | -.50$^c$ | .43$^d$ | .26 | -.07 | .68$^a$ |
| Surface | .15 | -.53$^b$ | .41$^d$ | -.02 | .21 | .75$^a$ | .18 | -.36 | .49$^c$ | .24 | .06 | .62$^b$ |
| FALL | | | | | | | | | | | | |
| Bottom | -.22 | .32 | .64$^b$ | .63$^b$ | .52$^c$ | .68$^a$ | -.41$^d$ | .13 | .72$^a$ | .66$^a$ | .32 | .76$^a$ |
| Mid-Depth | -.19 | .27 | .60$^b$ | .68$^a$ | .43$^d$ | .64$^b$ | -.38$^d$ | .16 | .74$^a$ | .66$^a$ | .31 | .75$^a$ |
| Surface | -.08 | .27 | .50$^c$ | .67$^a$ | .43$^d$ | .66$^a$ | -.36 | .18 | .76$^a$ | .60$^b$ | .26 | .75$^a$ |

[a] significant at $P = 0.001$ [b] significant at $P < 0.01$ [c] significant at $P < 0.05$ [d] significant at $P < 0.1$

Table 3.2.2-17. Summary of reported commercial landings (lbs) of selected fish species in Lake Erie..

| | WHITE BASS | | WHITE PERCH | | GIZZARD SHAD | |
|---|---|---|---|---|---|---|
| Year | Lake Erie | Long Point Bay[1] | Lake Erie | Long Point Bay[1] | Lake Erie | Long Point Bay[1] |
| 1971 | 92,027 | 23,869 | --- | --- | --- | --- |
| 1972 | 1,755,858 | 49,099 | --- | --- | --- | --- |
| 1973 | 1,496,885 | 13,079 | --- | --- | --- | --- |
| 1974 | 2,346,146 | 22,461 | --- | --- | --- | --- |
| 1975 | 2,563,103 | 9,820 | --- | --- | --- | --- |
| 1976 | 1,120,408 | 27,386 | --- | --- | --- | --- |
| 1977 | 986,283 | 14,237 | --- | --- | --- | --- |
| 1978 | 1,648,767 | 9,379 | --- | --- | --- | --- |
| 1979 | 1,679,487 | 29,018 | --- | --- | --- | --- |
| 1980 | 1,972,594 | 17,438 | --- | --- | --- | --- |
| 1981 | 1,936,423 | 78,698 | 467 | 206 | --- | --- |
| 1982 | 3,458,005 | 517,318 | 3,822 | 0 | 3,750 | 0 |
| 1983 | 4,576,753 | 276,212 | 63,329 | 3 | 252,225 | 49,475 |

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[1] Data are from Statistical District 4.

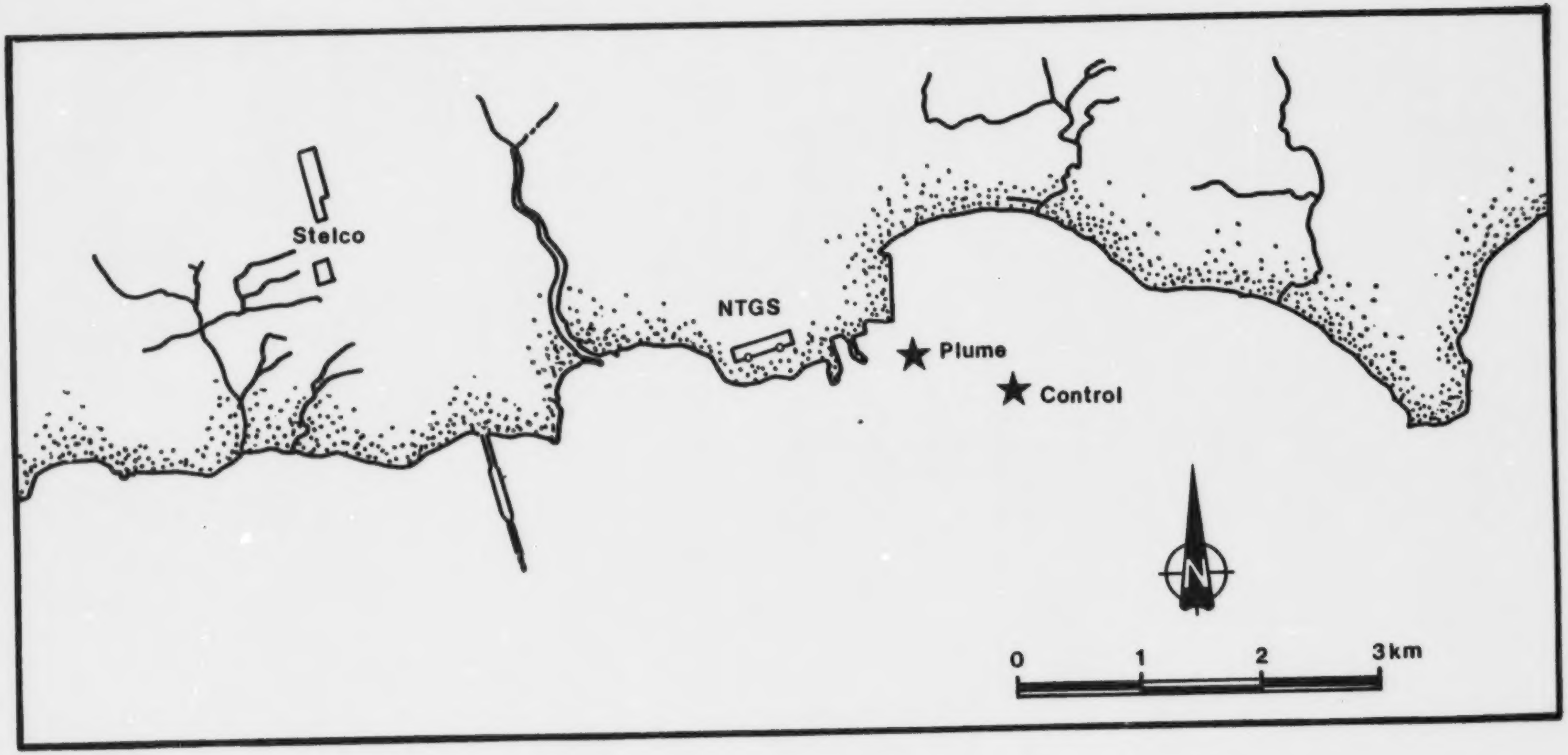
Stelco
NTGS
Plume
Control
N
0
1
2
3km

Figure 3.2.2-1. Gillnet sampling locations near the Nanticoke Thermal Generating Station, Long Point Bay, Lake Erie 1974-1983).

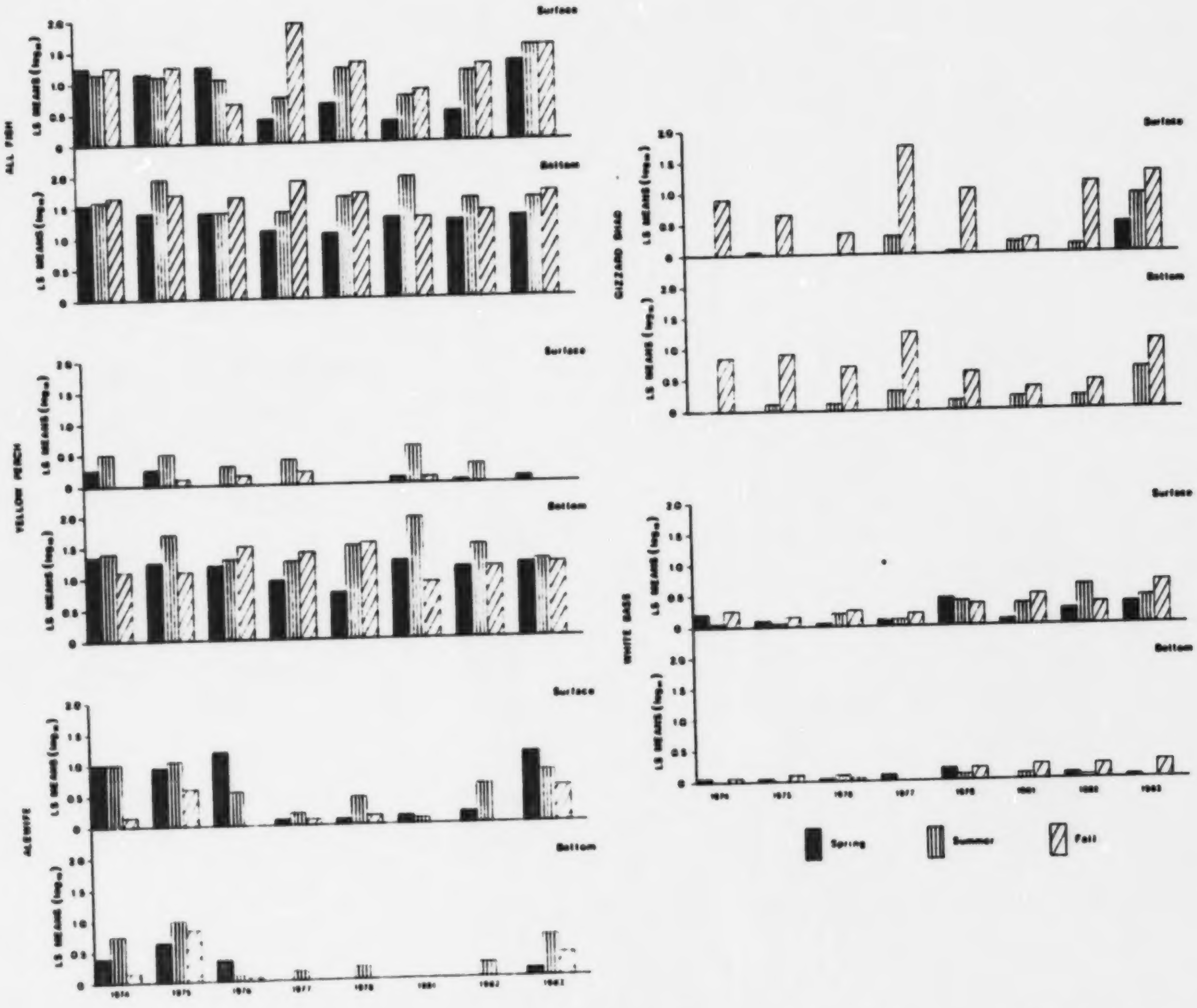

Figure 3.2.2-2. Yearly and seasonal summaries of least square mean number of selected fish species caught per lift in gillnets at Nanticoke (pooled locations), Long Point Bay, Lake Erie.

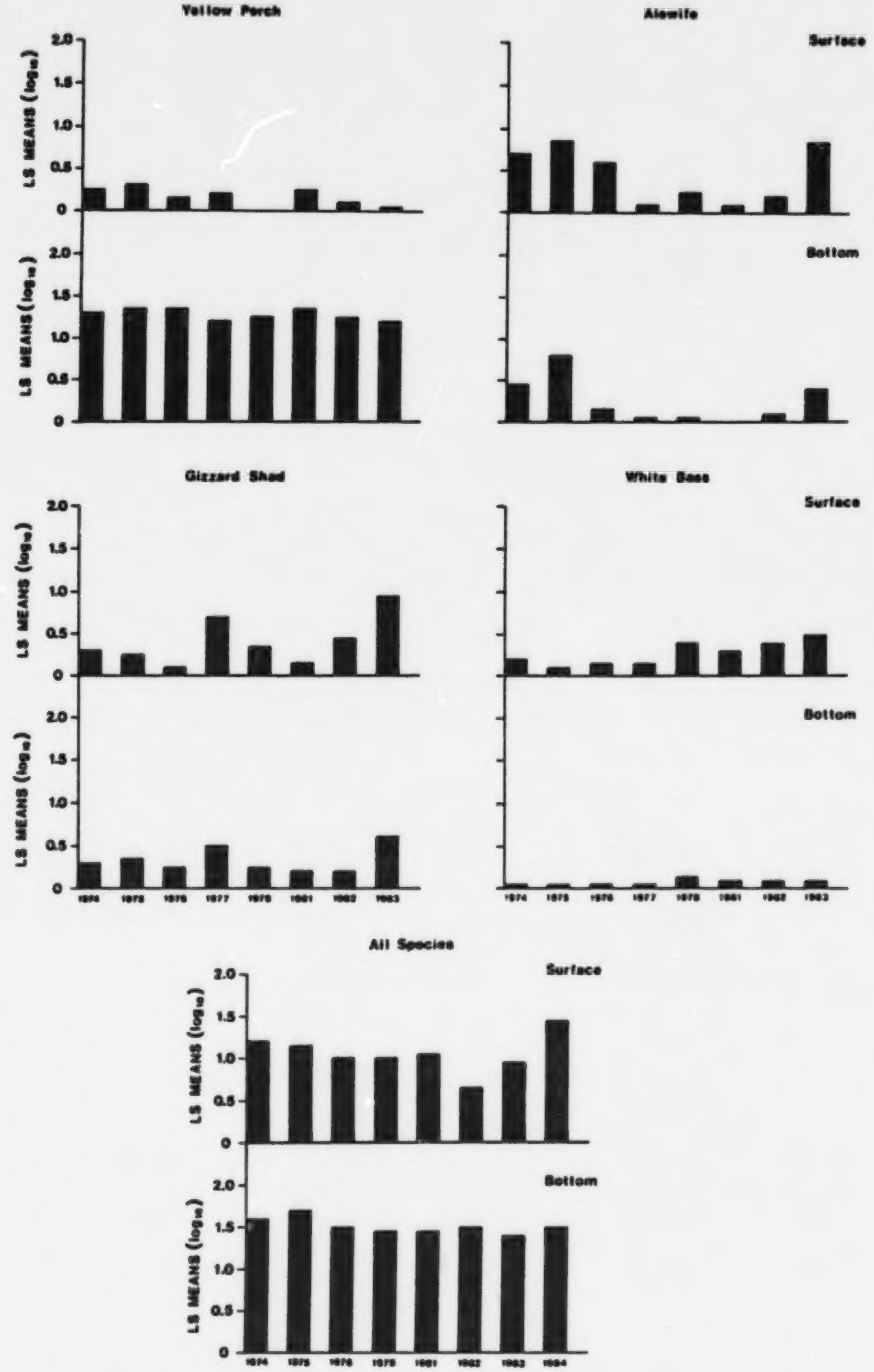

Figure 3.2.2-3. Least sqaures mean number of selected fish species caught per lift in gillnets at Nanticoke (pooled locations and seasons), Long Point Bay, Lake Erie.

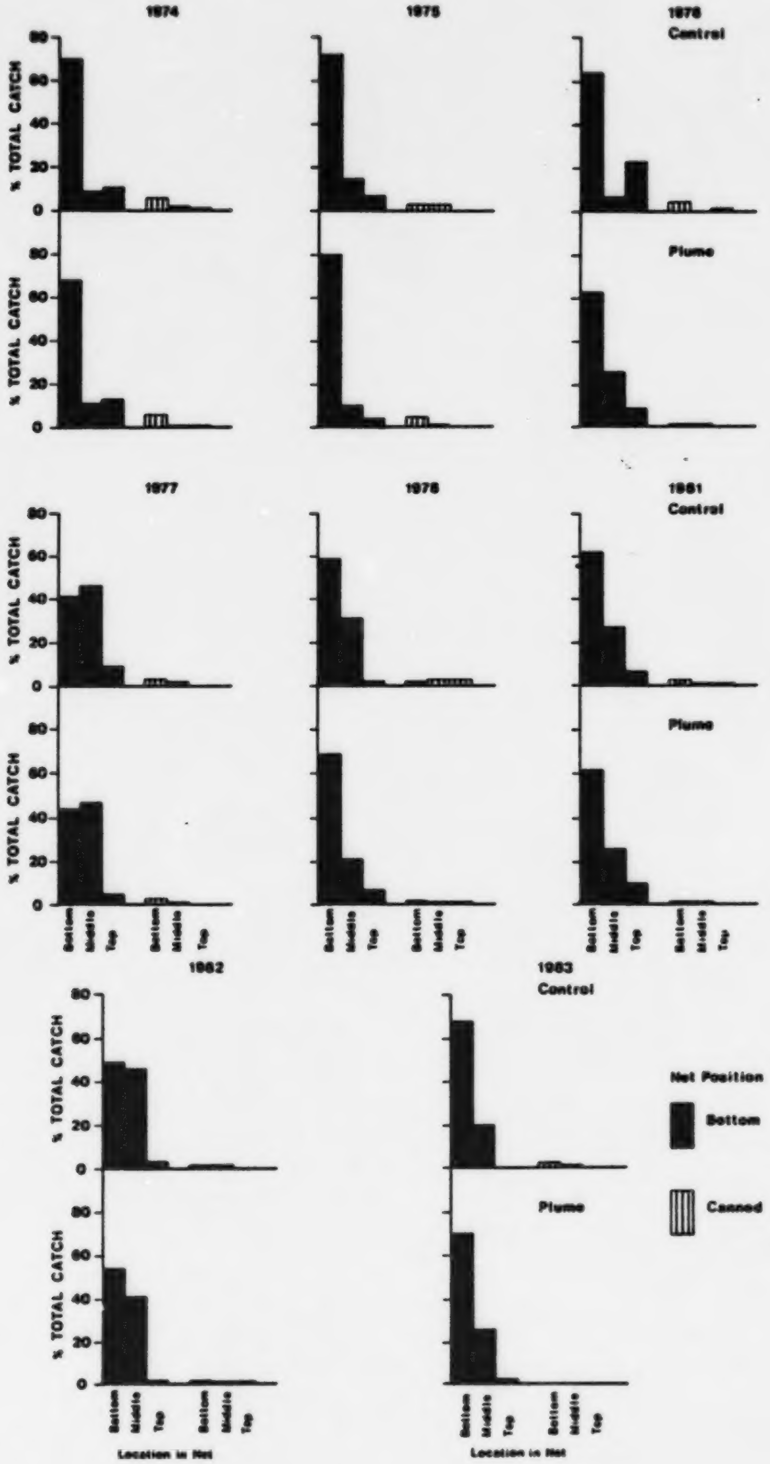

Figure 3.2.2-4. Distribution of yellow perch catches within surface (canned) and bottom gillnet sets at Nanticoke, Long Point Bay, Lake Erie.

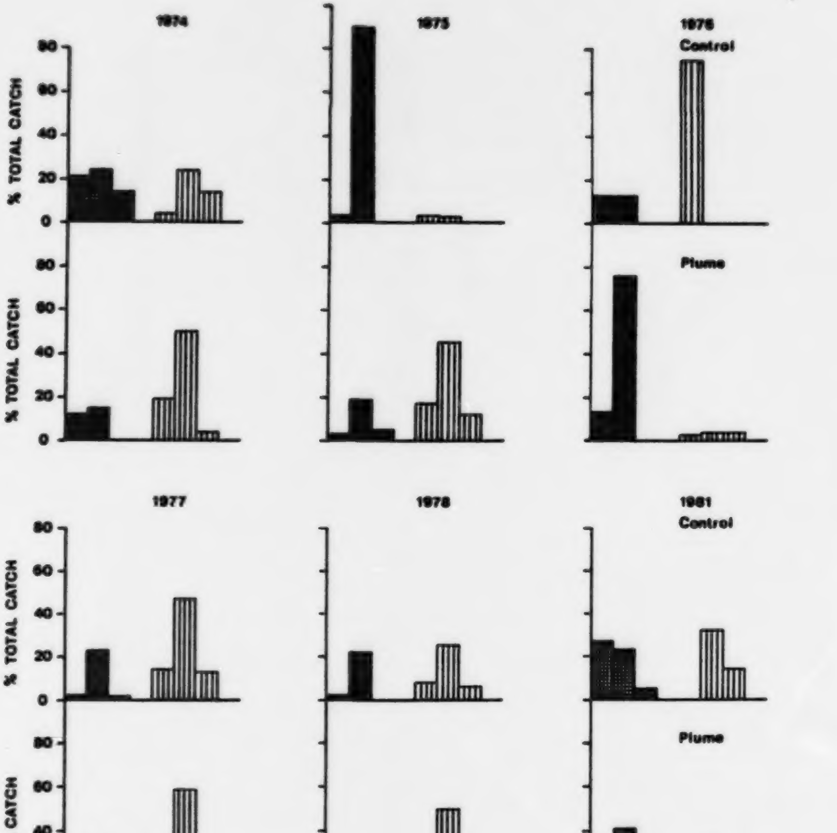

Figure 3.2.2-5. Distribution of gizzard shad catches within surface (canned) and bottom gillnet sets at Nanticoke, Long Point Bay, Lake Erie.

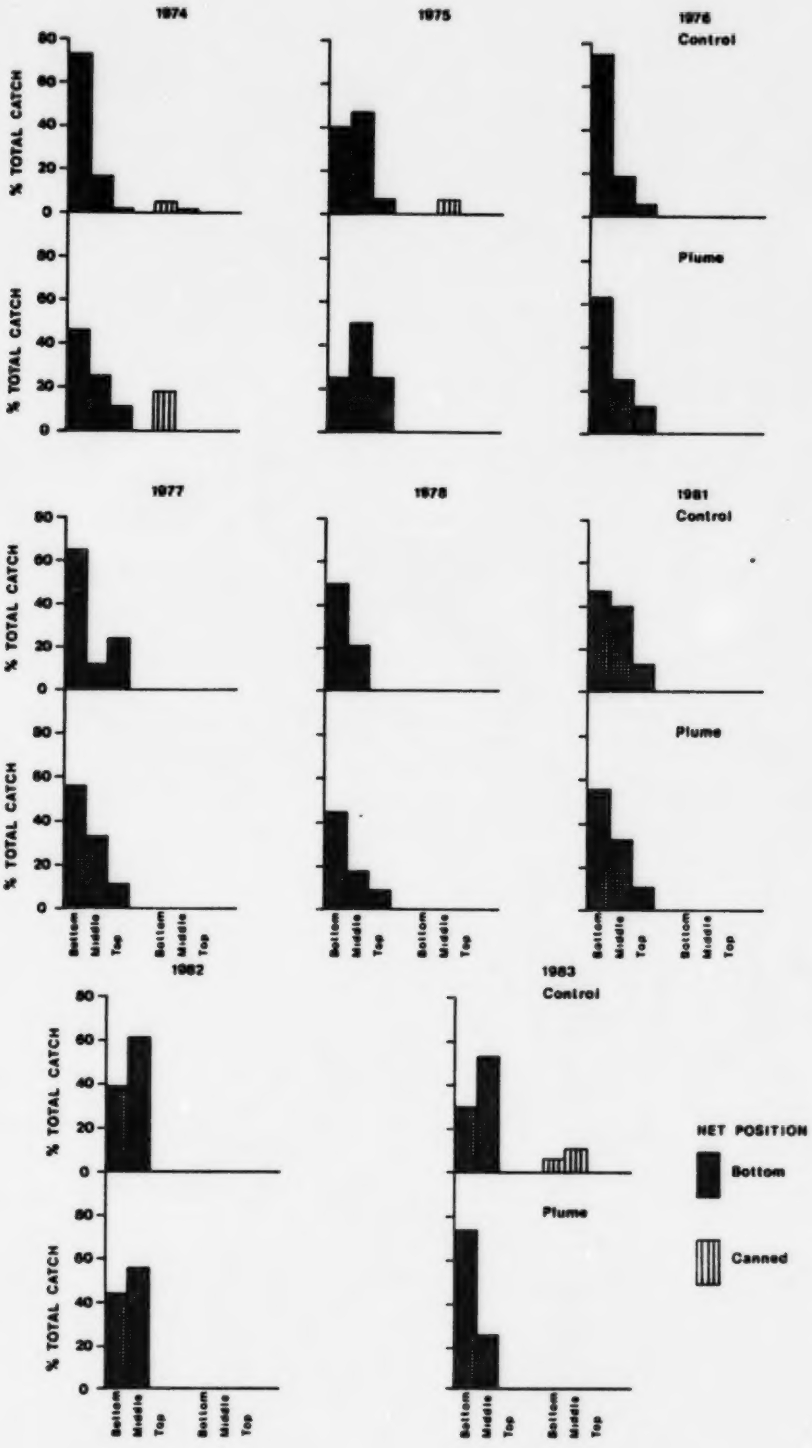

Figure 3.2.2-6. Distribution of sheepshead catches within surface (canned) and bottom gillnet sets at Nanticoke, Long Point Bay, Lake Erie.

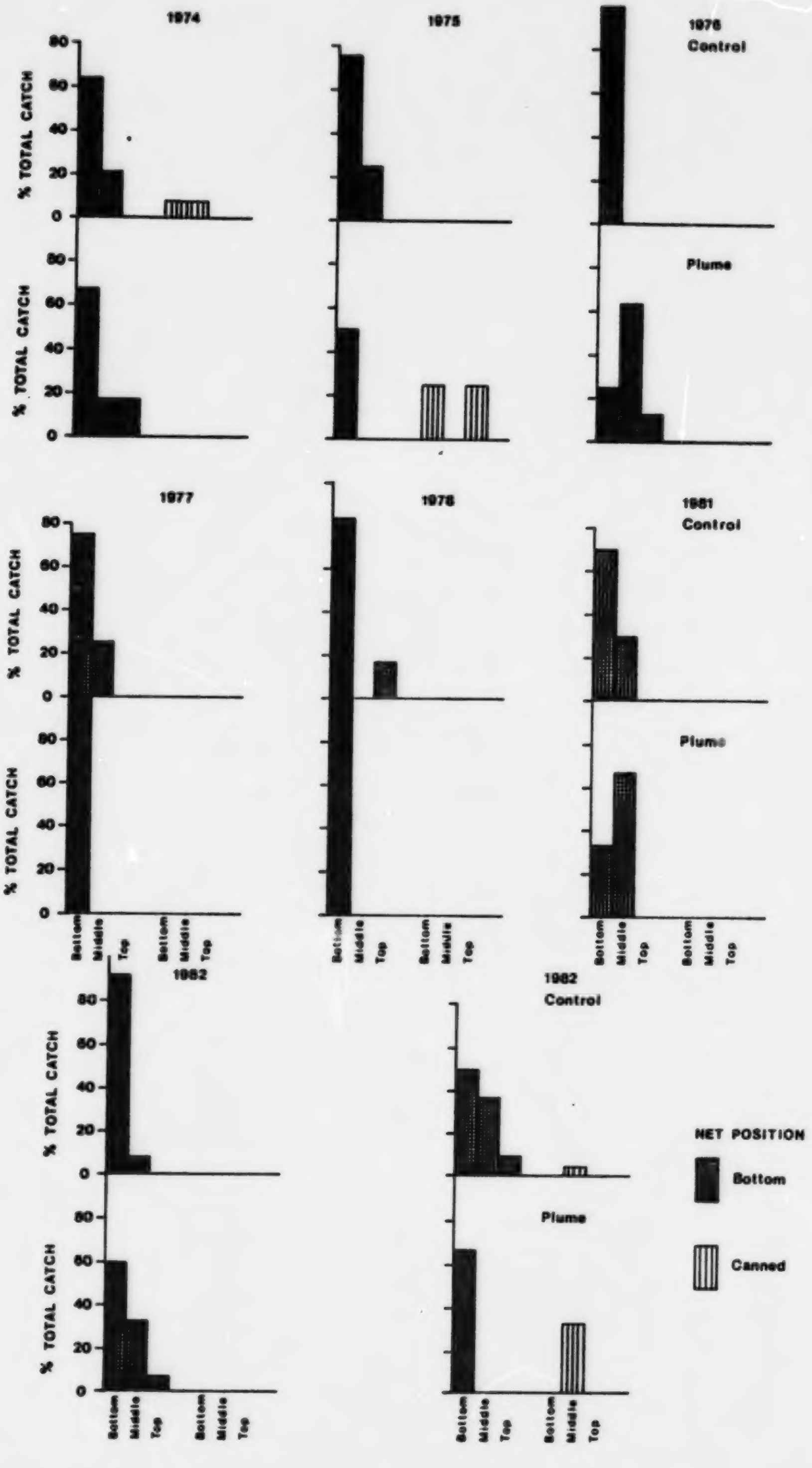

Figure 3.2.2-7. Distribution of smallmouth bass catches within surface (canned) and bottom gillnet sets at Nanticoke, Long Point Bay, Lake Erie.

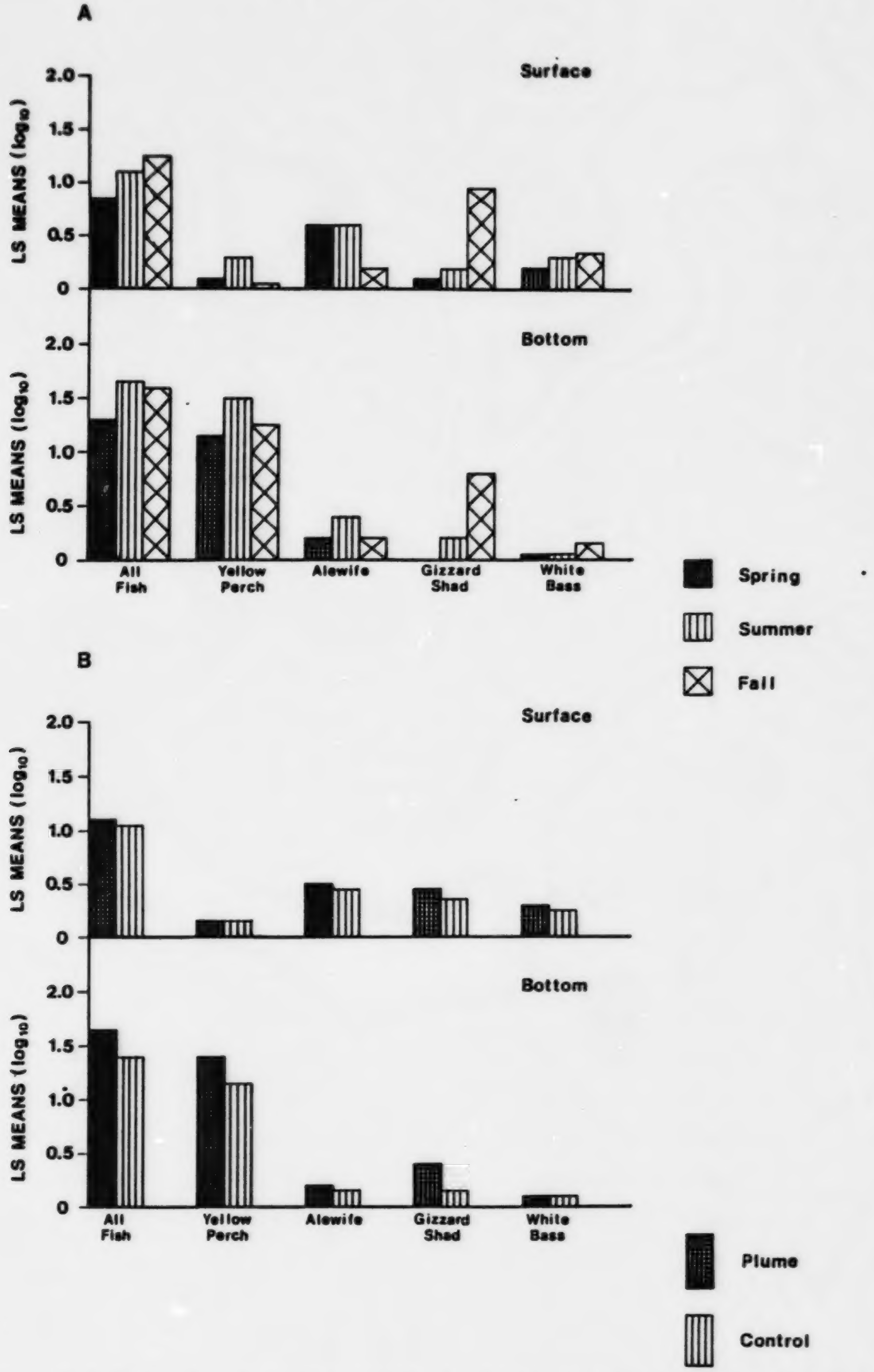

Figure 3.2.2-8. A. Seasonal trends in least squares mean number of selected fish species caught per lift in gillnets at Nanticoke (pooled years and locations).

B. Comparison of least squares mean number of selected fish species caught per lift in gillnets set at the plume and control locations.

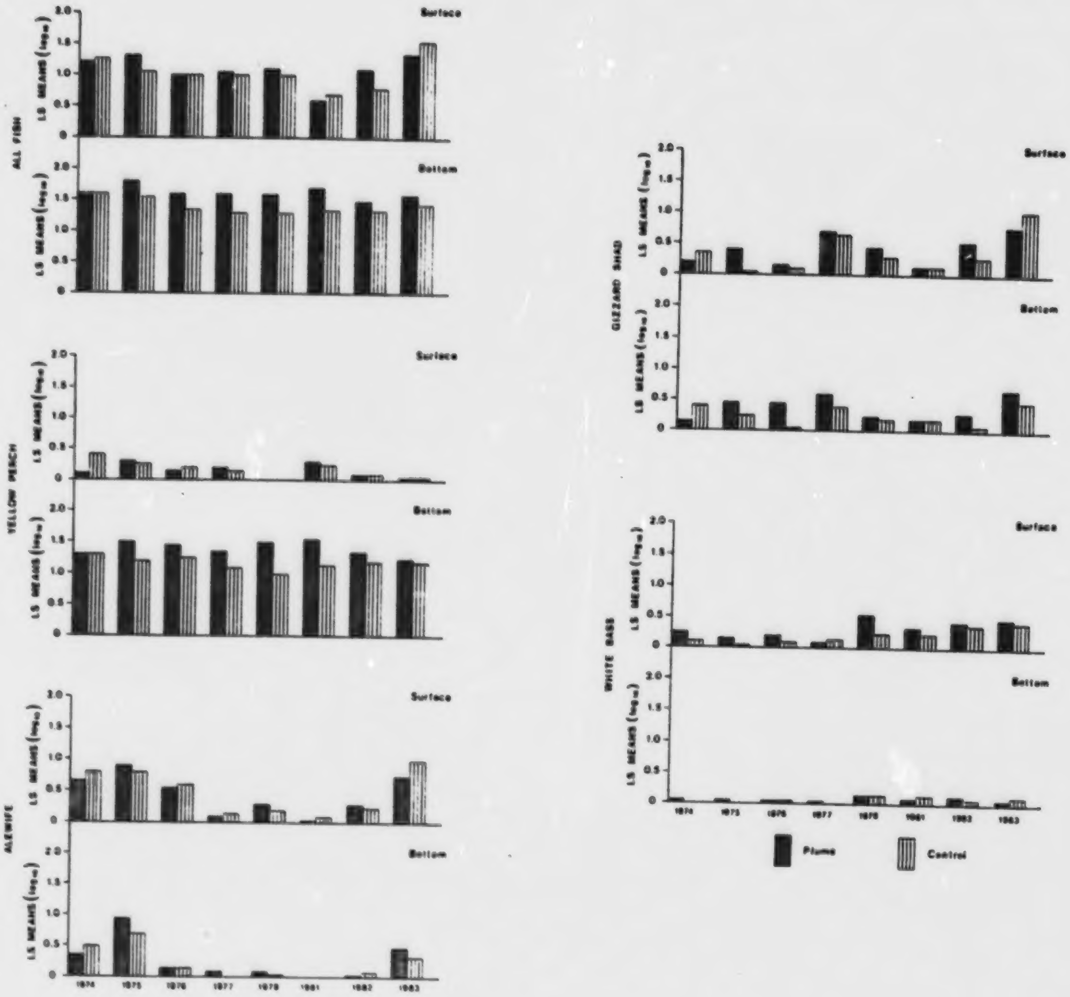

Figure 3.2.2-9. Yearly comparisons between locations of least square mean number of selected fish species caught per lift in gillnets at Nanticoke, Long Point Bay, Lake Erie.

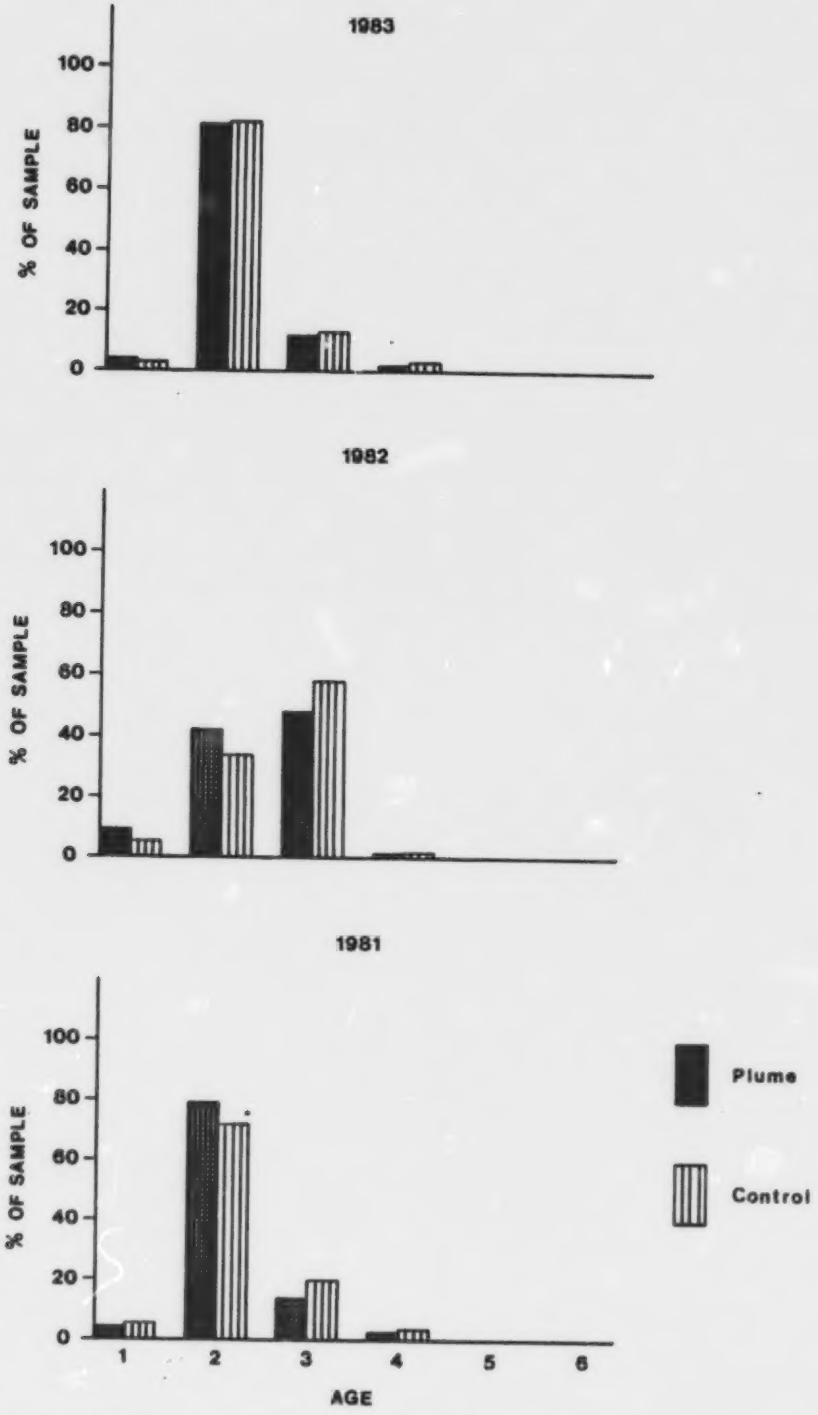

Figure 3.2.2-10. Age composition of yellow perch gillnet catches at Nanticoke, Long Point Bay, Lake Erie (1981-1983).

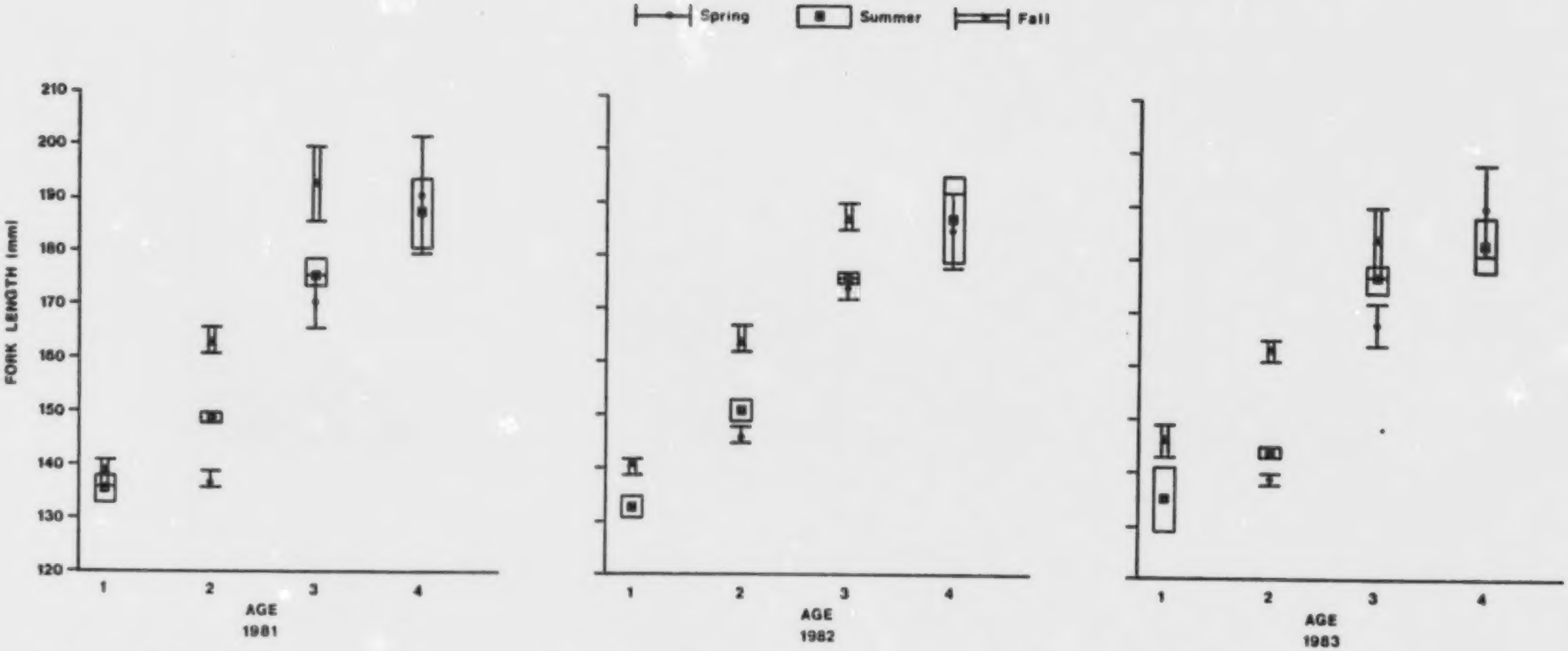

Figure 3.2.2-11. Seasonal changes in mean fork lengths at age of yellow perch caught by gillnets (1981-1983) at Nanticoke, Long Point Bay, Lake Erie (vertical bars represent 95% confidence intervals).

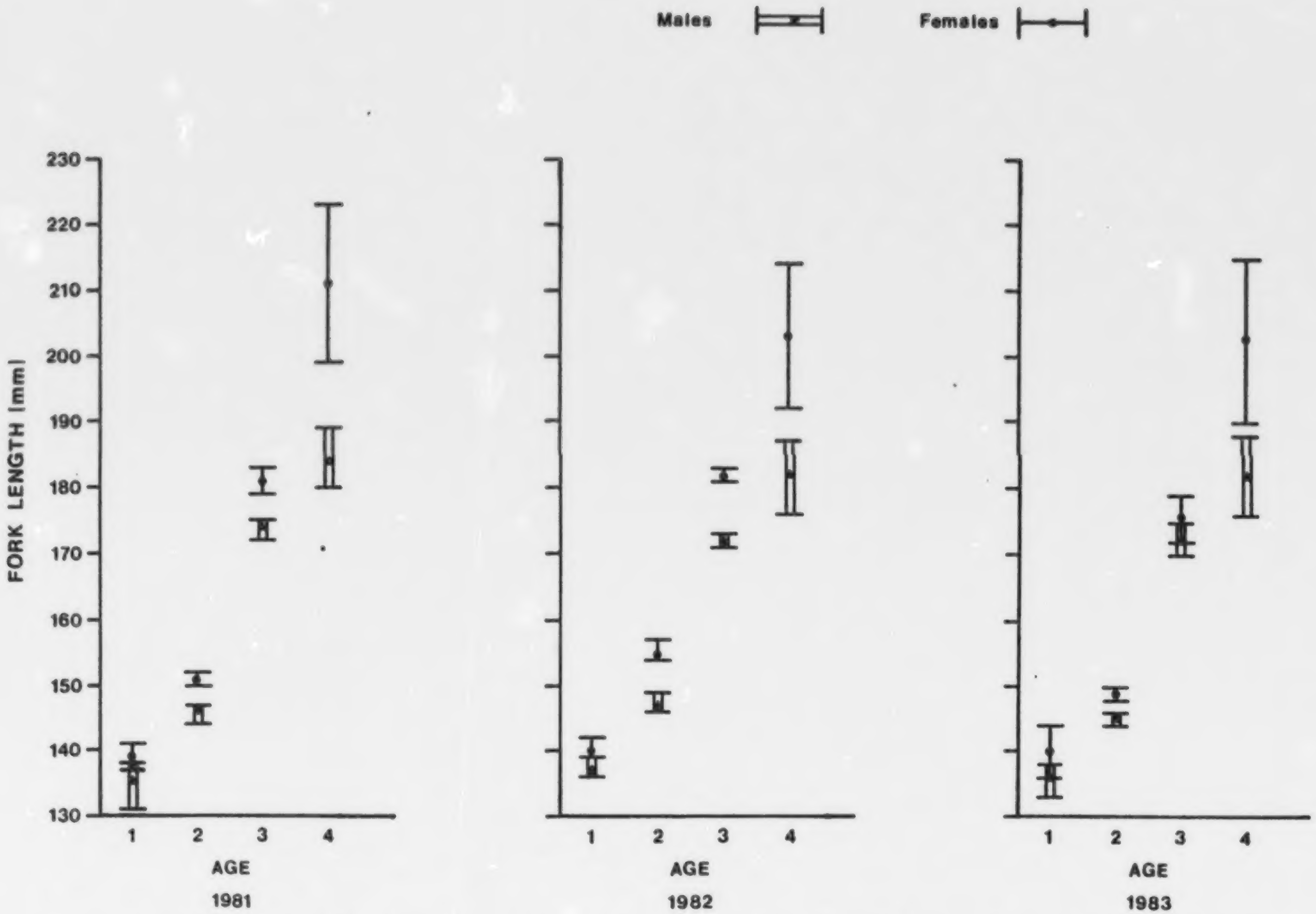

Figure 3.2.2-12. Mean fork lengths at age of male and female yellow perch caught by gillnets (1981-1983) at Nanticoke, Long Point Bay, Lake Erie.

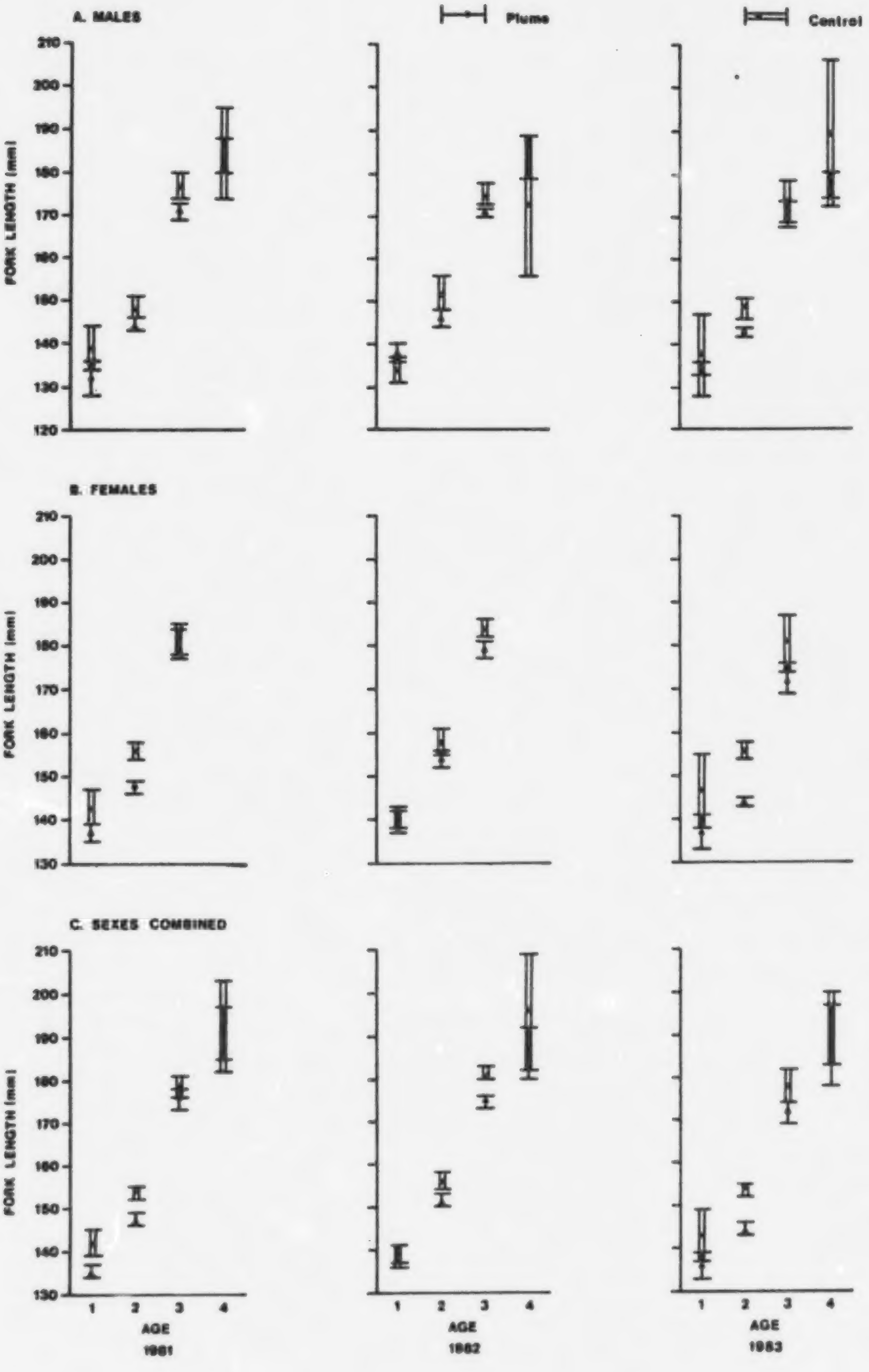

Figure 3.2.2-13. Mean fork lengths at age of yellow perch caught by gillnets (1981-1983) at Nanticoke, Long Point Bay, Lake Erie (vertical bars represent 95% confidence intervals).

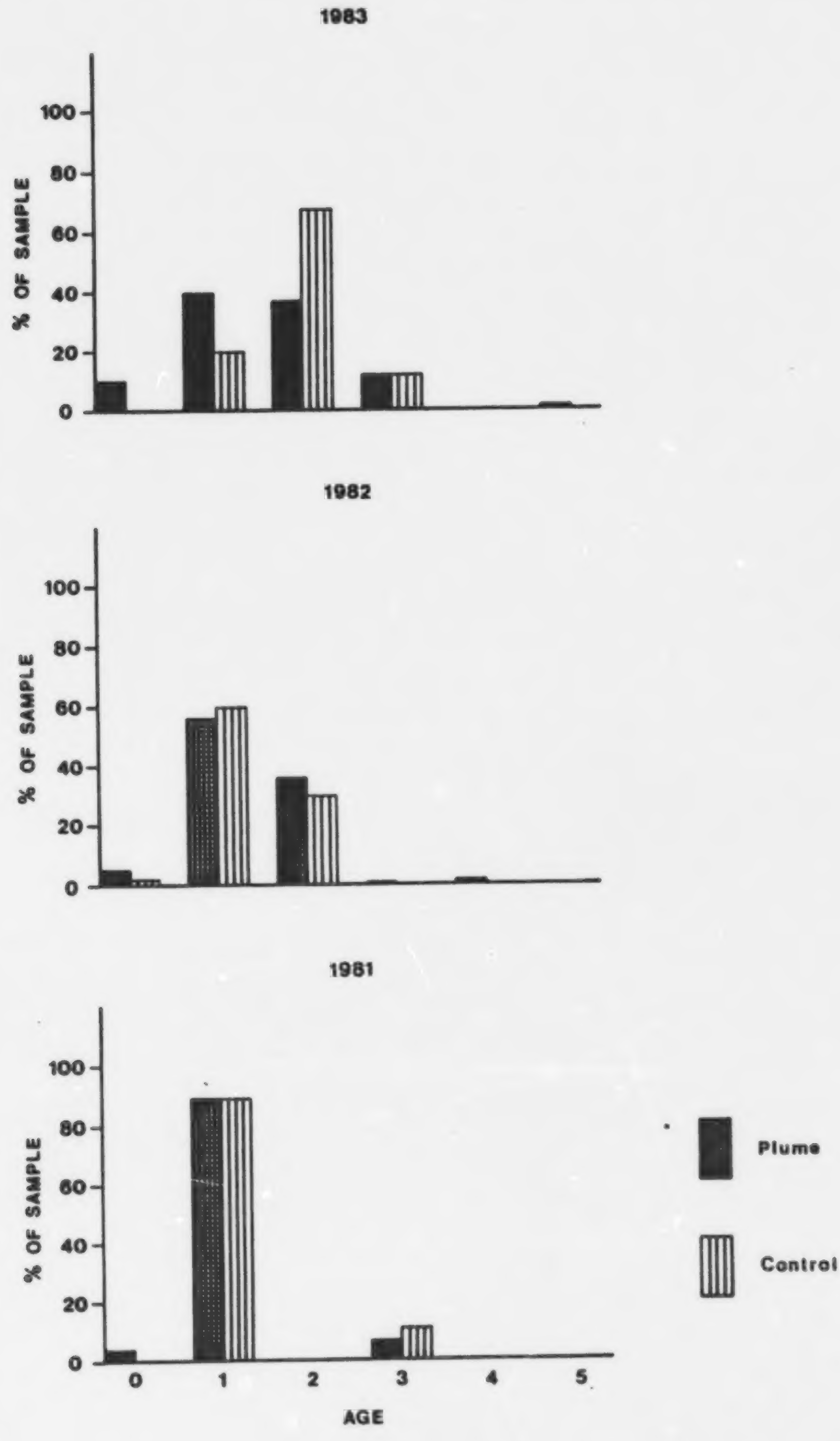

Figure 3.2.2-14. Age composition of white bass gillnet catches at Nanticoke, Long Point Bay, Lake Erie (1981-1983).

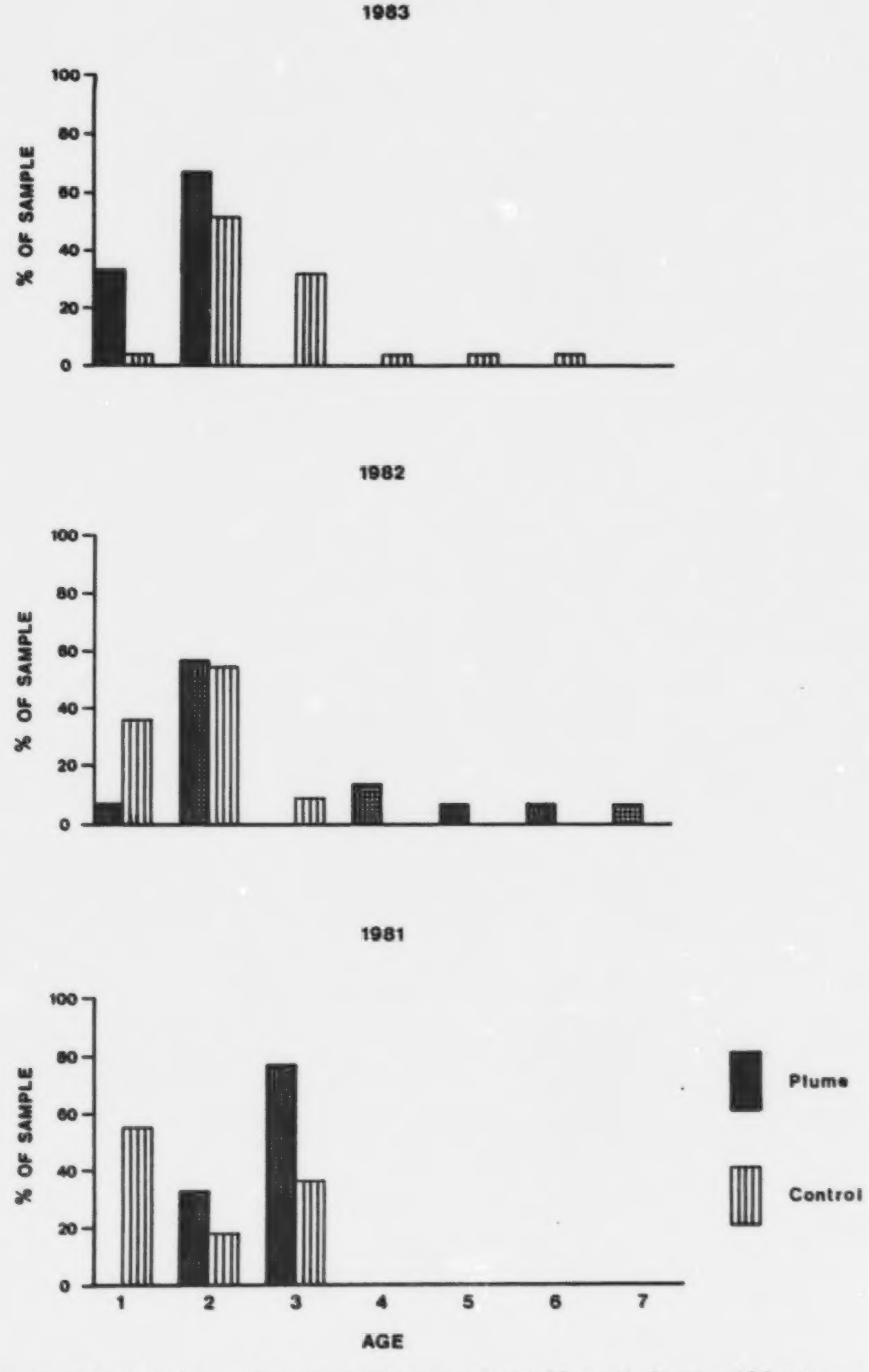

Figure 3.2.2-15. Age composition of smallmouth bass gillnet catches at Nanticoke, Long Point Bay, Lake Erie (1981-1983).

### 3.2.3 Sport Fishing in Long Point Bay

#### Introduction

Long Point Bay has been long regarded for its sport fishing opportunities (OMNR 1976, Stanley 1978, Sztramko and Paine 1984). Although smallmouth bass is the favoured target of most anglers in these waters, the annual harvest is comprised of some 15 or more species of which yellow perch and northern pike are taken year-round.

Sport fishing along the bay's north shore is concentrated near the port villages of Port Dover, Port Ryerse, Fishers Glen, and Normandale. These sites feature coldwater tributaries, which in the spring and fall attract a variety of pacific salmon and trout species. Fishing for salmonids is mostly by boat near the mouth and from shore at the mouth to several kilometers inland. Recently, a deep-water fishery for salmonids has developed near the tip of Long Point (Sztramko 1983).

East of Port Dover, angler densities are sparse with one exception - fishing pressure (primarily for white bass) on the heated outfall of the Nanticoke Thermal Generating Station (NTGS) has grown since the mid-seventies to approximately 15,000 rod-hours annually (Witzel 1984, 1985b). Some fishing for yellow perch and smallmouth bass occurs also on the reefs offshore of Nanticoke, but the extent and nature of this fishery is not known, and it is considered to be small in comparision to the more popular fishing grounds in western Long Point Bay.

The majority of angling pressure in Long Point Bay is expended in Inner Bay and to a lesser extent near the north shore of Long Point. Not surprisingly, the majority of assessment work on sport fishing in the bay has been on this area (Berst 1951, Lockhart 1981, Reid 1984b). Creel census surveys by the Ontario Ministry of Natural Resources (and predecessors) date back to 1948, but the data are scattered in unpublished reports. Lockhart (1981) and Hamley et al. (1981) have summarized creel census data for the years 1971-1978; thereafter, data have been documented in annual reports (Owen 1980, Powell 1980, Miller 1983, Reid 1984a, b).

Fisheries data from annual monitoring of the Long Point Bay sport fishery (summer and winter) have provided the only source of long term information for assessing trends and fluctuations in fish populations in Inner Bay and vicinity in relation to industrialization at Nanticoke (trapnet sampling in western Long Point Bay was discontinued in 1973).

Creel census methods in Long Point Bay have been standardized only since 1978; the objectives were to:

i) quantify angler effort,

ii) estimate angler catch, harvest, and success rates,

iii) examine the age and length composition of selected species in the harvest, and

iv) determine the percentage of resident and non-resident anglers.

This report summarizes the information available on the summer boat and winter ice fisheries on Long Point Bay from 1978 to 1983. In addition, estimates of angler success rates (CUE and HUE) for the period coinciding with the fish studies at Nanticoke (1971-1983) are reported. Not described here are the "specialized" fisheries, such as the spring smelt netting and pike spearing fisheries, and the salmonid lake/stream fisheries; documentation of these are found in Sztramko and Paine (1984) and in unpublished MNR reports (eg. Reid 1977a, b). The NTGS sport fishery is described in Section 3.2.4.

## Methods

### A. Summer Boat Fishery

A roving on-water creel census utilizing standardized procedures and systematic sampling within a 4-dimensional stratified design was carried-out each year in western Long Point Bay since 1978. Spatial (area) and temporal (month, day-type, time-period) stratification were incorporated to minimize sampling biases and to improve precision of parameter estimates.

The survey area was that part of outer Long Point Bay and Inner Bay lying west of a line extended between Turkey Point village and Bluff Bar point (Figure 3.2.3-1). This line coincided with the western boundary to commercial gill netting and trawling; it was marked by channel buoys spaced approximately 1 mile apart. The surface waters west of this line were subdivided into three census areas. Area 1 was west of a line extended between the St. William's lighthouse and Old Cut Channel. The area east of this line was bisected into a north (Area 2) and south (Area 3) component by a boundary extended roughly in line with the existing east-west channel markers.

The bottom sediment in Area 1 is largely mud (Heathcote 1981), covered by a dense growth of macrophytes, mostly water milfoil (Myriophyllum spicatum), bushy pondweed (Najas flexilis), and wild celery (Vallisneria americana) (Smith 1979). Area 1 is the smallest of the three areas at 2,368 ha (Area 2 - 5,032 ha; Area 3 = 10,397 ha). The eastern portion of Inner Bay (Areas 2 and 3) is primarily sand or sandy-mud; muskgrass (Chara vulgaris) is the predominate vegetaion type, but bushy pondweed and wild celery are also common.

Most of Inner Bay's shoreline is cattail (Typha spp.) marsh. Mean depth of Inner Bay is 1 m, but water levels in the shallow bay and surrounding marshes are largely influenced by those in Lake Erie (Berst and MacCrimmon 1966) and, consequently may fluctuate considerably on an annual, seasonal, and daily basis. Such fluctuations, depending on their severity and timing, probably have an important effect on fish populations, local fisheries (sport and commercial), and boating in this area (pers. comm., D. Reid). Water temperatures in Inner Bay generally range from 10-25°C during the summer (June - August) (Leach 1981). The portions of Areas 2 and 3 lying within outer Long Point Bay are considerably deeper (to 10 m) and surface water temperatures average 2 - 5°C cooler than in Inner Bay.

Boat parties gained access to the survey areas from more than a dozen private marinas dispersed along the north and west shores from Turkey Point village to Old Cut channel. Access was also possible from a boat launch in Long Point Provincial Park.

The summer angling season was stratified into three periods: i) May - June, ii) July, and iii) August. In most years since 1978 the creel census began in May, usually in the first week; however, in 1978 and

1982 the survey did not begin until June (Table 3.2.3-1). Except for 1978, all survey days prior to opening day of bass season (usually the last Saturday in June) were treated as the first period. The remaining part of June and all of July were treated as the second period, and August as the third. The 1978 creel census began on June 20 and survey periods in that year corresponded to the calendar months (June, July, August), ie., June was not divided according to days open versus closed to bass fishing.

Days were stratified according to type: weekdays versus weekends (including holidays). Weekdays were scheduled independently of weekends and the latter day-type was sampled more intensely because fishing pressure generally was much greater on weekends than weekdays.

Days were also stratified into two 7-hr time periods, AM (0700 - 1400 h) versus PM (1401 - 2100 h), to ensure complete surveillance of a normal daylight fishing period (approx. 14 h) and to accommodate the regular 8-h work day of the survey crew.

Sampling among the 36 strata (3 areas x 3 months x 2 day-types x 2 time-periods) was scheduled systematically. At least two samplings (replicates) were assigned to each stratum (per year) to enable calculation of the standard error of the catch, harvest, and effort estimates; however, uncontrollable factors (weather and mechanical problems) prevented complete replication (2 or more samples) of all strata in some years.

The creel census crew, consisting of a boat operator and creel clerk, operated from a 6.4-m boat powered by a 175 kW inboard/outboard engine and were based either in Turkey Point Marina or an OMNR boat house in Old Cut. They carried with them sampling equipment to measure length and weight of selected fishes, and interview forms on which to record particulars about each boat party's fishing trip.

In a given 7-h sampling period, the census crew surveyed two of three areas. Two boat counts were made per area not closer than one hour apart. Boat parties were interviewed at random. As many interviews were performed as time would allow without jeopardizing time needed to complete each boat count. Boat counts of zero (nil) were assigned to days when foul weather prevented the safe operation of a boat by the census crew.

Fork length (FL) and total length (TL), body weight, and scale samples were obtained from harvested smallmouth and largemouth bass, yellow perch, rock bass, and northern pike. These samplings were collected on board the survey boat during scheduled census periods, and periodically at dock side. Cleithra were removed from some northern pike to assist in age determination.

Analyses of creel census data were performed by APL computer programs developed by the Lake Erie Fisheries Assessment Unit (Petzold 1980). Catch, harvest, and effort estimates for individual strata were derived from daily (based on 7-h AM or PM census periods) observed measures of the same data summed over all days within a stratum. Weathered-out days exhibiting little or no fishing pressure were included in the analyses.

Effort was expressed in angler-hours and in rod-hours; only the latter measure was used in estimates of catch, harvest, and cath per unit of effort (CUE) because not all members of a boat party were actively fishing when interviewed. However, non-fishing members were treated as anglers because they had few alternative recreational activities in which to participate.

Catch per unit of effort (CUE) and harvest per unit of effort (HUE) were derived for "all anglers" and for anglers seeking a particular species (species anglers). An "all-angler" CUE (or HUE) was equal to the observed total number of a species caught (or harvested) divided by the observed total number of rod-hours expended by all anglers. A species-angler CUE was equal to the observed catch (or harvest) of a species divided by the observed number of rod-hours expended by anglers seeking that species. CUE's (or HUE's) were used in this report as measures of relative fish abundance.

## B. Winter On-Ice Fishery

Through-the-ice fishing on Long Point Bay is centered primarily in Inner Bay near St. Williams. Fishing begins when solid ice forms, usually early - late January and often lasts until early March. Fish huts are available for rent from two commercial operators in St. Williams. Upwards of 400 - 600 private huts are erected each year and many anglers fish out in the open. Most anglers seek yellow perch and usually fish one or two lines baited with live minnows.

Creel censuses of the winter ice fishery were carried out in 1972 to 1980 and 1982. No census was operated in 1981 or 1983. Census methods were the same in all years except for the latter half of 1982. Morning and afternoon periods were censused on weekdays and weekends at prescheduled times. A creel census clerk walked clockwise around the fishing area interviewing as many fishing parties as possible. Uncensused huts were counted in 1976, 1978 and 1979 as were uncensused anglers that fished on the open ice in 1978 and 1979.

In 1982, the creel census procedures were modified from a roving incomplete-trip design to a restricted access complete-trip design. A check-point station was established near the lighthouse in St. Williams to count and interview anglers as they left the ice surface after completing their fishing trip. Access to and from the ice fishing areas was mostly near the check-point station. Anglers were interviewed systematically at a frequency determined by the out-bound volume of traffic. Counts of anglers leaving the ice were totaled hourly from 1031 to 1730 h. Adjustments to angler counts were made to account for possible over estimations due to out-bound anglers passing through the check point, but later returning to fish again in the same day.

Before 1974, the kinds of information recorded were hours fished by anglers (angler-hours) and numbers of fish harvested. After 1974, catch, harvest, and effort in rod-hours were recorded.

Data analysis was similar to that of the summer census. Angler success rates were calculated for all years, but those prior to 1974 were expressed only as harvest per unit of effort (HUE) because the number of fish caught was not recorded in those years. Total fishing effort, catch, and harvest were estimated only since 1978 because complete counts of the number of huts-in-use and number of anglers fishing out in the open were not determined prior to 1978.

## Results

### A. Summer Boat Fishery

Creel census surveys on Long Point Bay since 1971 have varied in duration (59 - 132 days) and sampling frequency (18 - 53 samples) (Table 3.2.3-1). Estimates of total effort, catch, and harvest are available only since 1978 when sample design and scheduling were first standardized. Anglers were primarily of local origin; some 90% or more resided in Ontario, the remainder came from other provinces and the United States. They fished using a variety of techniques and baits, primarily casting and trolling with artificial lures, and drifting or still-fishing with worms, minnows or small crayfish.

#### (i) Distribution of Angling Effort

Anglers expended between 200,000 - 300,000 rod-hours annually during the summer boat fishery on Long Point Bay, 1978-1983 (Table 3.2.3-2). No year-to-year trend in effort was apparent. More rod-hours were fished in Area 3 (45 - 57% of annual total effort) than elsewhere in all years (Figure 3.2.3-2). Conversely, Area 1 received the least amount of effort (7 - 17% of annual total effort). The first five weeks after opening day of bass season (July and part of June) accounted for more than half (53 - 87%) of the summer fishing effort (Figure 3.2.3-3). Except in 1980, August was the second most heavily fished period in terms of total and mean daily effort. Almost two-thirds (60 - 73%) of total annual effort occurred on weekends; daily fishing pressure (mean rod-hours per day) was 3 - 6 times greater on weekends than weekdays (Table 3.2.3-3).

### (ii) Catch and Harvest

Between 300,000 and 700,000 fish (all species) were caught annually by anglers on Long Point Bay from 1978 to 1983, but only 32 - 48% were harvested (Table 3.2.3-4). The combined catches of yellow perch, rock bass, and smallmouth bass accounted for 80% or more of the total catch (in number) in all years; a substantial portion of the perch (40 - 60%) and rock bass (65 - 83%) catches were released. Some 15 other species were caught each year from 1978 to 1983. Of these, largemouth bass (1 - 2% of total annual catch, northern pike ($\leq$ 1%), freshwater drum (5 - 9%), sunfish (3 - 8%), and crappies ($\leq$ 1%) were the most common. White bass were caught in significant numbers for the first time in 1983 (n = 2,838).

### (iii) Yellow Perch

Anglers seeking yellow perch accounted for 18 - 38% of the total annual effort (rod-hours) since 1979 (Table 3.2.3-5). The percentage of boat parties seeking perch generally was highest in May - June when the harvesting of bass was prohibited. Total estimated catch of perch ranged between 100,000 and 300,000 per year since 1978 (Table 3.2.3-4). Some 40 - 50% of all perch caught were harvested. The relative distribution of the total catch and harvest of perch among the three survey areas did not vary across years (1978 - 1983): catch and harvest were highest in Area 3, followed by Areas 2 and 1 (Figure 3.2.3-2). Yellow perch fishing was good in all three survey areas; CUE's ranged between 1 and 4 perch per rod-hour for anglers seeking this species (Table 3.2.3-6).

Although yellow perch fishing generally improved with season, most yellow perch were caught in July when fishing effort was the most intense (Table 3.2.3-6, Figure 3.2.3-3). Perch fishing typically was best during August; perch anglers in that month averaged 2.77 to 5.59 perch/rod-hour, 1978 - 1983. The large perch catches observed in 1979 - 1981 coincided with increased CUE's (for all anglers) (Figure 3.2.3-4). Harvested yellow perch in 1982 and 1983 were mostly ages III to V (Table 3.2.3-7).

### (iv) Smallmouth Bass

Smallmouth bass were the most sought after species on Long Point Bay; 59 - 84% of the total angling effort was directed annually at this species (Table 3.2.3-5). Their desirability was reflected in the harvested portion of the total catch (74 - 80% kept annually) (Table 3.2.3-4). Total catches of smallmouth bass in 1982 (n = 89,301) and 1983 (n = 90,052) were well above those in the earlier years (n = 50,190 - 79,572), probably because of increased angling pressure and availability of harvested year classes. Total smallmouth bass catch and total angling effort were weakly associated ($r = 0.753$; $df = 4$, $P > 0.05$) over the survey years; CUE's (for all anglers) were highest in 1982 and 1983 (Figure 3.2.3-4).

Total catch and harvest of smallmouth bass were highest in Area 3 and lowest in Area 1 (Figure 3.2.3-2). This pattern was consistent across years (1979-1983). July produced the largest catches of smallmouth bass and was the best month of fishing for this species (0.29 - 0.45 bass/rod-hour) (Figure 3.2.3-3).

Annual harvests of smallmouth bass were represented by 6 to 8 year classes, mostly ages III - V (Table 3.2.3-7).

### (v) Largemouth Bass

Largemouth bass received much less directed fishing pressure than did smallmouth bass (3 - 9% total annual effort) (Table 3.2.3-5). Largemouth bass represented only 2% or less of the total annual catch since 1978, but catches have increased noticeably in recent years, apparently in response to an increase in the numbers of anglers seeking this species (Table 3.2.3-4).

Annual catches of largemouth bass were highest in Area 1 or 3, but fishing success was generally best in Area 1 (species angler CUE = 0.23 - 0.64) and the worst in Area 3 (0.13 - 0.42) (Table 3.2.3-6 and Figure 3.2.3-2). More largemouth bass were taken in July than at any other time (Figure 3.2.3-3). Success rates for bass anglers were also highest in July (0.28 - 0.58 bass/rod-hour). CUE's (for all anglers) of largemouth bass have increased since 1977 (Figure 3.2.3-4). Most harvested bass were two to five years old.

### (vi) Northern Pike

Northern pike were not heavily sought by anglers in the summer boat fishery. Pike accounted for only 5% or less of the total angling effort and 1% or less of the total catch annually since 1979 (Tables 3.2.3-4 and -5). Approximately half of the 3,000 - 7,000 pike caught annually were harvested. Total catch and pike-angler success rates were highest in Area 3 (Table 3.2.3-6, Figure 3.2.3-2). Pike fishing was best in May - June and more pike were caught then than at any other time (Figure 3.2.3-3).

Anglers (all anglers) harvested an average of 0.01 - 0.02 northern pike per rod-hour in most years since 1971 (Figure 3.2.3-4). In 1973, 1974 and 1976 the average HUE was 0.03 pike per rod-hour. CUE estimates (for all anglers) indicate that anglers experienced above average catch success of northern pike in 1976 and 1977 (CUE's = 0.03). Total pike catch and angling effort were weakly ($P > 0.05$) associated from 1978 to 1983 ($r = 0.790$; $df = 4$). Harvested pike in 1983 were primarily age IV (Table 3.2.3-7).

### (vii) Rock Bass

The proportion of the total angling effort directed at rock bass varied annually (1979 - 1983) between 5 and 12% (Table 3.2.3-5). Rock bass were the principal species caught (35 - 44% of total catch) in Long Point Bay in most years, and second only to yellow perch in some years (Table 3.2.3-4). Total annual catches of rock bass approximated 250,000 fish in 3 of 6 years since 1978. Annual catches were significantly correlated ($r = 0.829$; $df = 5$; $P \geq 0.05$) with total fishing pressure. About 1 in every 4 captured rock bass were kept by anglers. Total rock bass catch was consistently highest in Area 3 and lowest in Area 1 since 1978 (Figure 3.2.3-2). Catches of rock bass in July were twice as high as in any other month (Figure 3.2.3-3).

Catches of rock bass per unit of effort by anglers seeking this species did not vary greatly among the three survey areas, but exhibited significant declines with progression of season in most years (Table 3.2.3-6). The abundance of rock bass in Long Point Bay apparently has increased since 1975 based on improved catch rates for all anglers (Figure 3.2.3-4). Rock bass harvestd in 1983 were represented by 8 year classes, of which four to six year olds were the most common.

B. Winter Ice Fishery

Winter creel surveys were operated in most years since 1971, but estimates of total effort and harvest are available only since 1978 (Table 3.2.3-8). Estimates of angler harvest rate (HUE) are available for all years censused, but only for yellow perch and northern pike; catches (or harvests) of rainbow smelt and other incidental species were not always recorded before 1976.

Variations in total angling effort (47,000 - 127,000 rod-hours) were due largely to ice conditions (Table 3.2.3-8). Solid ice lasted several weeks in some years and only a few days in other years.

Some 93% or more of the total winter fish harvests between 1978 and 1982 consisted of yellow perch (Table 3.2.3-8). The highest recorded yellow perch harvest was in 1979 (n = 314,600). Some northern pike were taken in all years.

Anglers averaged in excess of 2 yellow perch per rod-hour in all years except for a 4-year period in 1975 - 1978 (Figure 3.2.3-5). Average HUE of yellow perch in 1980 was exceptionally good (5.91 perch/angler-hour) indicating an increased abundance of harvested year classes in that year. Harvests of rainbow smelt and northern pike per unit of effort by all anglers generally were poor; less than 0.1 fish per rod-hour in most years since 1971.

## Discussion

The summer and winter sport fisheries on Long Point Bay were the largest anywhere in the Canadian waters of Lake Erie (Table 3.2.3-10). Effort exerted by anglers in the summer boat fishery in Long Point Bay was two or more times greater than in Rondeau Bay, the Western Basin, and the Detroit River. Harvest compositions of the Long Point Bay and western Lake Erie sport fisheries were different as well. Walleye and white bass were the major species taken in the Western Basin and Detroit River, but were of minor importance in Long Point Bay. Conversely, large catches of rock bass, largemouth bass, and northern pike were taken by anglers in Long Point Bay, but not in the Western Basin or Detroit River. Yellow perch and freshwater drum were common in all the sport fisheries surveyed on Lake Erie by OMNR.

Estimates of mean daily effort provided the best indication of trends in fishing pressure in Long Point Bay because length of the surveys was variable across years. No consistent pattern in fishing pressure was apparent since 1978 (Table 3.2.3-3); year-to-year fluctuations were probably related to weather conditions and quality of fishing.

Anglers were attracted to Long Point Bay in the summer primarily in pursuit of smallmouth bass. Opening day of bass fishing attracted upwards of 3,000 anglers (Stanley 1978). Several times more smallmouth bass were harvested in Long Point Bay than elsewhere on the Canadian waters of Lake Erie (Table 3.2.3-4 and -10). Anglers fished mostly in the southwest portion of Inner Bay (Area 3), because fishing opportunities for smallmouth bass were better there than anywhere else (Table 3.2.3-6). This area is also an important spawning ground of smallmouth bass (Goff 1984, Pynenburg and Witzel 1985). A sanctuary was established (1983) in the eastern half of Inner Bay to minimize possible interference with nesting bass by anglers primarily fishing for yellow perch and northern pike during closed bass season. In an earlier (1956 - 1967) installation of a no-fishing sanctuary in Inner Bay, Sztramko (1985) found that CUE's of smallmouth bass were significantly higher during years the sanctuary was in effect than in the post-sanctuary period (1968 - 1981). Improved CUE's may have been the result of the availability of harvest-size bass following spawning or to increased recruitment; however, mean age of harvest data did not support either of these explanations (Sztramko 1985).

Some inferences about the general movements of smallmouth bass are possible from examination of the spatial distribution of angling effort. Fishing for smallmouth bass was best in the first few weeks following opening day. As water temperatures warmed through July and August, the distribution of anglers seeking bass shifted from Inner Bay to the deeper, cooler waters of outer Long Point Bay (Reid 1984b). This movement of bass presumably occurred in response to their preferred temperatures of about 21°C (Scott and Crossman 1973), which usually is exceeded in Inner Bay by late-July.

In general, catch and harvest were highest in Area 3 and lowest in Area 1, highest in July and lowest prior to opening of bass season (May - June). This pattern was consistent over years for most of the principal species, and apparently was a reflection of angling effort (Figures 3.2.3-2 and -3) as annual total angling effort was positively correlated ($P < 0.05$) with annual total catches of rock bass and to a lesser extent with total catches of smallmouth bass and northern pike. Total catches of yellow perch and largemouth bass were not significantly correlated with effort. For yellow perch, summer sport catches probably were influenced to some extent by the combined exploitation pressures of commercial gill netters in outer Long Point Bay, commercial hoop and seine netters in Inner Bay, and sport fishermen in the winter ice fishery. In particular, the winter ice fishery in Inner Bay harvested almost exclusively yellow perch ($\geq$ 93% of the winter harvest) and harvests were not restricted by possession limits. In years when both a winter and summer survey were operated, two to four times more perch were harvested through the ice than by the boat fishery the following summer. To what extent the ice fishery and commercial fisheries effect the quality of perch angling in the summer is not known.

Why annual catches of largemouth bass were not associated with total effort may be due to several reasons. Compared to other species, areas fished for largemouth bass were more specific (mostly fringe areas of marshes) and the methods of catching them more specialized. Only a small portion of the angling population sought this species and, probably, much fewer were proficient at it. Furthermore, some of the angling for largemouth bass occurred in the marshes outside the area of creel census surveillance.

That most largemouth bass were taken in Area 1 despite much greater (83% or more) expenditures of effort elsewhere (Table 3.2.3-2) can be explained in terms of the distribution of preferred largemouth bass habitat and the accessibility of these areas to anglers. Although most of the Inner Bay shoreline is marsh, the fringe area between marsh and open water, the preferred habitat of largemouth bass, is considered to be more extensive in Area 1 than in the other survey areas (pers. comm., D. Reid). Most of the fringe area, but none of the inner marshes were surveyed before 1984. Consequently, little is known about the sport fishing activities in the privately owned Turkey Point (bordering Area 2) and Long Point (bordering Area 3) marshes. The Crown Land Marsh located along the south border in Area 1 was readily accessible to anglers. The importance of this marsh to the largemouth bass fishery was identified in an independent survey in 1984 (Halyk 1985). Almost three-quarters (74%) of the anglers fishing in the crown marsh during the open season sought largemouth bass. They expended some 3,500 rod-hours in catching an estimated 1,800 largemouth bass. This expenditure of effort is equivalent to about one-sixth to one-half the amount directed at largemouth bass annually (7,600 - 23,000 rod-hours) during the open season in Long Point Bay since 1979.

Year-to-year variations in total catch and sport fishing success were also influenced by abundance of the various species, but we were unable to examine fully the importance of year-class strengths for most species because age composition data were not available. Some general comparisons for yellow perch were possible.

| Indices of yearling Yellow Perch Abundance in Western Lake Erie | | Estimated stock size of Age 2 and older Yellow Perch in Eastern Lake Erie | | Angler Success Rates for Yellow Perch (all ages) in Long Point Bay | | |
|---|---|---|---|---|---|---|
| Year | Index[1] | Year | No. x $10^5$[2] | Year | HUE[3] | CUE[4] |
| 1969 | 3.79 | 1971 | 77 | 1971 | 2.34 | |
| 1970 | 5.35 | 1972 | 114 | 1972 | 4.78 | |
| 1971 | 5.51 | 1973 | 187 | 1973 | 2.96 | |
| 1972 | 3.38 | 1974 | 122 | 1974 | 2.40 | 0.51 |
| 1973 | 3.63 | 1975 | 94 | 1975 | 0.82 | 0.51 |
| 1974 | 5.05 | 1976 | 61 | 1976 | 1.35 | 0.46 |
| 1975 | 4.90 | 1977 | 85 | 1977 | 0.95 | 0.40 |
| 1976 | 3.73 | 1978 | 56 | 1978 | 1.28 | 0.50 |
| 1977 | 6.00 | 1979 | 77 | 1979 | 3.44 | 1.24 |
| 1978 | 3.67 | 1980 | 82 | 1980 | 5.91 | 1.26 |
| 1979 | 4.32 | 1981 | 77 | 1981 | | 0.87 |
| 1980 | 5.50 | 1982 | 49 | 1982 | 4.79 | 0.74 |
| 1981 | 4.16 | 1983 | 70 | 1983 | | 0.78 |

[1] Index = LN(No./trawl-hour), OHIO Department of Natural Resources
[2] Estimates were derived from cohort analysis (Baker *et al*. 1985)
[3] No. harvested per angler-hour by all anglers
[4] No. caught per rod-hour by all anglers

According to U.S. and Canadian sources the 1977 year class of yellow perch was very strong throughout Lake Erie. That year class first showed strongly in the Long Point sport fishery as two year olds in 1979, and subsequently as three and four year olds in 1980 and 1981, respectively. Angler success rates during the summer and winter sport fisheries in 1979 to 1981 were the highest observed in Long Point Bay since 1971.

The fish community in Long Point Bay, particularly in reference to Inner Bay, has undergone vast changes since sport and commercial fishing began on the bay in the 1800's (Whillans 1977, 1979). While exploitation undoubtedly has imposed stress on fish populations in

Long Point Bay, so have other human activities. Development of marshland and shoreline, sedimentation, eutrophication, and introductions of exotic species have contributed to shifts in species composition in the past 100 years (Regier and Hartman 1973, Leach and Nepszy 1976, Regier et al. 1980). Changes in the Inner Bay fisheries since 1971 have been far less dramatic and are difficult to explain in relation to industrial development at Nanticoke. Some of the alterations we observed are not unique to this fishery but are reflections of processes occuring lake-wide. Changes, such as increased catches of white bass were not surprising in light of the general expansion of this species throughout Lake Erie.

Angler catches of white perch in Inner Bay have not reflected recent significant increases of this species in outer Long Point Bay (Tables 3.2.1-7 and 3.2.2-1). The eutrophic waters of Inner Bay (Leach 1981) likely would favour population growth of white perch (Christie 1974), but an abundance of predators (northern pike, smallmouth bass) may preclude their development as a dominant member of the fish community (pers. comm., S. Nepszy). Apparent increases in abundance of rock bass (increased CUE's) in Inner Bay have not reflected trends in catches of this species in trap nets at Nanticoke. The reasons for this are not clear and we can only speculate that year-to-year market fluctuations in the commercial hoop and seine net fisheries and in predator abundance were possible contributing factors.

Increased angler catches/harvests and CUE's (all anglers) of largemouth bass since 1979 may be misleading (Figure 3.2.3-4). Observed trends of these variables were influenced to a large extent by fluctuations in the effort directed specifically at this species.

For the period in which data were available (1979 - 1983), the percentage of total angling effort exerted on largemouth bass was significantly ($P \leq 0.05$) correlated with total catch ($r = 0.884$) and harvest ($r = 0.903$) of largemouth bass and with the all-angler CUE's ($r = 0.913$). All-angler CUE's, which are derived from the catch and effort of anglers seeking any species or no species in particular, do not accurately index the abundance of a species through time if the amount of effort directed at that species varies sigificantly from year to year in relation to the annual total effort. CUE's derived from only the catch and effort of anglers seeking a particular species are not biased in this manner. CUE's of largemouth bass anglers indicate there is no discernible trend in abundance for this species from 1979 to 1983 (Table 3.2.3-6). Why largemouth bass increased in popularity after 1980 (Table 3.2.3-5) is not clear, but some authorities speculate that decreased angling success for smallmouth bass in Inner Bay and the collapse of the largemouth bass fishery in Rondeau Bay were contributing factors (pers. comm., D. Reid).

Angler success rates (CUE's and HUE's) of northern pike have fluctuated considerably (by as much as 3x) since the early seventies (Figure 3.2.3-4), but not in any recognizable pattern that can be attributed to exploitation. The sport harvest of northern pike is relatively small (< 8,000 pike/year) and commercial fishing is confined to only a few weeks in the spring and fall with pike harvests restricted to 1,000 lb. per fishery (in 1983). Fluctuations in the abundance of northern pike in Long Point Bay are more probably related to annual water levels and its associated effects on reproductive success, and the availability of spawning and nursery habitat (Johnson 1957, Kipling and Frost 1970, Hassler 1979, Nelson 1978).

Smallmouth bass, the principal target species of anglers in Long Point Bay, have exhibited signs of decreased abundance during the study years (1971 - 1983). Management efforts to counter this apparent trend have included the establishment of a sanctuary during the spawning period. For other species additional measures may be needed to reverse present trends. New quota restrictions have been placed on most commercially harvested species, and possibly to come are restrictions on the sale of yellow perch by sport fishermen, which in some winters has been substantial. Some argue that the future of the Long Point Bay fishery is more closely linked to preservation and maintenance of shoreline marshes, than to management of the fisheries (Hamley _et_ _al_. 1981).

Although our scientific knowledge of fish populations in Inner Bay is not extensive, we found no evidence to suggest that the Long Point Bay sport fishery, concentrated primarily in Inner Bay, has been influenced by industrialization at Nanticoke. The following rationale was considered:

(i) ultrasonic telemetry and mark-recapture studies indicate that neither Stelco's dock nor industrial discharges (Chamberlain 1979, see Section 3.2.5) interfered with the along-shore migrations of fish (some extending into Inner Bay);

(ii) water currents in Long Point Bay are such that industrial discharges do not mix within Inner Bay except possibly in very dilute amounts during lake seiches;

(iii) trends in angler catch/harvest rates for the major species in Long Point Bay show little or no relationship to industrial activities over the commissioning and operational periods; and

(iv) fluctuations in year-class strengths, changes in angling pressure (eg. increased fishing effort directed on largemouth bass after 1980), and cultural stresses (eg. exploitation) appear to have influenced trends in the sport fishing to some extent.

We think that many of the fluctuations in the Long Point Bay sport fishery (trends in catch/harvest and angler success rates) can be attributed to changes in year-class strengths (more specifically, to the environmental factors which determine year-class strengths). This is not an unreasonable assumption considering the importance of Inner Bay and its surrounding marshes as a major spawning and nursery area, and the vulnerability of these waters to fluctuations in water temperature, water levels, and wave activity.

## Summary

The summer sport fishery on Long Point Bay is concentrated in Inner Bay and along the southwestern portion of the outer bay from Bluff Pt. to Turkey Pt. In winter, sport fishing activities are centred on the ice near St. Williams. The summer and winter sport fisheries on Long Point Bay are among the largest on Lake Erie. Combined, they amount to some 300,000 to 400,000 rod-hours of fishing annually, of which most is directed at smallmouth bass in the summer and yellow perch in the winter. Anglers participating in these fisheries were predominately of local origin $\geq$90% Ontario residents).

Variations in total angling effort during the summer boat fishery (200,000 - 300,000 rod-hours, annually) probably were due to annual variation in weather and fishing quality. Similarly, duration of (few days to several weeks), and total fishing pressure exerted during (<100,000 - 127,000 rod-hours) the winter sport fishery were largely influenced by ice conditions from year to year.

Total annual catch of the summer boat fishery since 1979 ranged between 300,000 and 700,000 fish, but less than half of this number were harvested. Yellow perch, rock bass and smallmouth bass comprised 80% or more of the total catch in all years. Some 15 other species also were caught each year, of which largemouth bass (1-2% of total summer catch), northern pike (<1%), freshwater drum (5-9%), sunfish (3-8%), and crappies (<1%) were the most common.

Spatial and seasonal variation in total catch and harvest of individual species, and in total fishing pressure were strongly influenced by the fishing activities of anglers seeking smallmouth bass. This group of anglers alone accounted for as much as 80% of the total summer angling effort. In general, most of the summer angling pressure, and highest catches of most species occurred in the southern part of Inner Bay and along the north shore of Long Point (Area 3) because fishing opportunities for smallmouth bass were better there than anywhere else. Similarly, total fishing pressure and catches of the major species (yellow perch, rock bass) were highest in July when smallmouth bass fishing was the best (mean species angler CUE 1978 - 1983 = 0.29 - 0.45 smallmouth bass/rod-hour).

The spatial distribution of largemouth bass catches did not follow the above pattern. Instead, total catches and CUE's of this species generally were highest in the western part of Inner Bay (Area 1), primarily because an abundance of preferred bass habitat was accessible to anglers there. In contrast, access to the privately owned marshes in Turkey Pt. (Area 2) and Long Point (Area 3) were restricted.

Angler catch success (CUE) of the major species harvested in the summer boat fishery varied significantly over seasons, probably in response to changes in fish availability and/or behavior (eg. feeding patterns). For example, CUE's of smallmouth bass decreased through summer because adult bass, which congregated in Inner Bay during the spawning season (late May-June), presumably dispersed into the deeper, cooler waters of outer Long Point Bay as water temperatures in Inner Bay rose above the basses' preferred range (approx. 21°C) (see descriptions of fish migrations in Section 3.2.5).

Changes in the Long Point Bay sport fishery since 1971 bear no apparent relationship with industrial activities at Nanticoke. Annual fluctuations in catches were due partly to year-to-year variations in total fishing pressure (in rod-hours). Catches of smallmouth bass and northern pike were weakly associated ($P > 0.05$) with total fishing pressure and catches of rock bass were significantly ($P < 0.05$) correlated with total fishing pressure. An increase in annual catches of largemouth bass since 1981 was due to increased numbers of anglers seeking this species. The reason for the recent rise in popularity of largemouth bass are unclear, but may be related to a decline in the quality of smallmouth bass fishing and to the collapse of the largemouth bass fishery in Rondeau Bay, Lake Erie.

We suspect that much of the annual fluctuations in catch and fishing success were due to year-class strengths, but we were unable to conclusively demonstrate this for any species because of insufficient age-composition data from sport harvests. Year-class strengths, recruitment, and sport yields of Long Point Bay fish populations are influenced to some degree by natural fluctuations in environmental variables (water level, temperature, turbidity) and by cultural factors (exploitation, eutrophication, shoreline develoment, marsh reclamation). Both can impose signficant stresses on fish populations, particularly those inhabiting the highly productive, but ecologically sensitive waters in and around Inner Bay during the most critical life stages (reproduction and larval development). Regulation of the sport and commercial fisheries by restricting the harvests of economically important species (eg. yellow perch), imposing no-fishing sanctuaries during critical periods (eg. smallmouth spawning sanctuary in Inner Bay), and preserving marsh areas are measures now being exercised by fisheries managers in an attempt to maintain viable fish populations and fisheries in Long Point Bay.

Table 3.2.3-1. Sampling frequency and period of summer creel surveys on Long Point Bay, 1971-1983[5].

| Year | First day of bass season | Census[1] Period | N[2] | n[3] | Dates |
|---|---|---|---|---|---|
| 1971 | June 26 | total | 65 | 19 | June 26 - Aug 29 |
| 1972 | June 24 | total | 75 | 41 | June 14 - Aug 27 |
| 1973 | June 30 | total | ND[4] | 23 | June ND - Aug ND |
| 1974 | June 29 | total | 59 | 24 | June 25 - Aug 22 |
| 1975 | June 28 | total | 74 | 23 | June 19 - Aug 31 |
| 1976 | June 26 | total | 67 | 19 | June 26 - Aug 31 |
| 1977 | June 25 | total | 68 | 18 | June 25 - Aug 31 |
| 1978 | June 24 | June | 11 | 6 | June 20 - June 30 |
|  |  | July | 31 | 11 | July 1 - July 31 |
|  |  | Aug | 31 | 11 | Aug 1 - Aug 31 |
|  |  | total | 73 | 28 | June 20 - Aug 31 |
| 1979 | June 30 | May-June | 60 | 16 | May 1 - June 29 |
|  |  | July | 32 | 16 | June 30 - July 31 |
|  |  | Aug | 31 | 15 | Aug 1 - Aug 31 |
|  |  | Sept | 9 | 6 | Sept 1 - Sept 9 |
|  |  | total | 132 | 53 | May 1 - Sept 9 |
| 1980 | June 28 | May-June | 54 | 18 | May 5 - June 27 |
|  |  | July | 34 | 15 | June 28 - July 31 |
|  |  | Aug | 31 | 15 | Aug 1 - Aug 31 |
|  |  | total | 119 | 48 | May 5 - Aug 31 |
| 1981 | June 27 | May-June | 46 | 15 | May 12 - June 26 |
|  |  | July | 35 | 15 | June 27 - July 31 |
|  |  | Aug | 31 | 9 | Aug 1 - Aug 31 |
|  |  | total | 112 | 39 | May 12 - Aug 31 |
| 1982 | June 26 | June | 25 | 12 | June 1 - June 25 |
|  |  | July | 36 | 19 | June 26 - July 31 |
|  |  | Aug | 31 | 14 | Aug 1 - Aug 31 |
|  |  | total | 92 | 45 | June 1 - Aug 31 |
| 1983 | June 25 | May-June | 55 | 17 | May 1 - June 24 |
|  |  | July | 37 | 20 | June 25 - July 31 |
|  |  | Aug | 31 | 14 | Aug 1 - Aug 31 |
|  |  | total | 123 | 51 | May 1 - Aug 31 |

[1] In 1978 to 1983, May and June were combined into one stratum when both months were surveyed. In 1978, the first 7 days of open bass season were included in the June stratum. After 1978, days in June corresponding to open bass season where included in the July stratum.

[2] N = total No. days in period.

[3] n = number of samples (1971-1977) or the number of days sampled (1978-1983); in 1971-1977, more than one sample was taken on some days.

[4] ND = Datum not known.

[5] Data taken from Lockhart (1981) and Reid (1984b).

Table 3.2.3-2. Distribution of estimated angling effort (EAE) and mean daily effort (MDE) by area and month in the summer sport fishery on Long Point Bay, 1978 - 1983.[1]

| Month | Year | Area 1 |  | Area 2 |  | Area 3 |  | Survey Area |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  | EAE | MDE | EAE | MDE | EAE | MDE | EAE | MDE |
| May - June | 1978 | 3666 | 333 | 13456 | 1223 | 7631 | 694 | 24753 | 2250 |
|  | 1979 | 9667 | 161 | 10792 | 180 | 5422 | 90 | 25881 | 431 |
|  | 1980 | 9498 | 176 | 10352 | 192 | 22241 | 412 | 42091 | 779 |
|  | 1981 | 7162 | 156 | 11595 | 252 | 17179 | 373 | 35936 | 781 |
|  | 1982 | 1190 | 48 | 4168 | 167 | 8040 | 322 | 13398 | 536 |
|  | 1983 | 7904 | 144 | 7137 | 130 | 14405 | 262 | 29447 | 535 |
| July | 1978 | 14671 | 473 | 48278 | 1557 | 46215 | 1491 | 109164 | 3521 |
|  | 1979 | 22400 | 700 | 65725 | 2054 | 113469 | 3546 | 201594 | 6300 |
|  | 1980 | 20303 | 597 | 50092 | 1473 | 68297 | 2009 | 138692 | 4079 |
|  | 1981 | 22563 | 645 | 64511 | 1843 | 109269 | 3122 | 196343 | 5610 |
|  | 1982 | 13308 | 370 | 87574 | 2433 | 136181 | 3783 | 237063 | 6585 |
|  | 1983 | 14292 | 386 | 73730 | 1993 | 111418 | 3011 | 199441 | 5390 |
| August | 1978 | 8873 | 286 | 24258 | 783 | 39791 | 1284 | 72923 | 2352 |
|  | 1979 | 9443 | 305 | 26904 | 868 | 15602 | 503 | 51949 | 1676 |
|  | 1980 | 7972 | 257 | 12167 | 392 | 18451 | 595 | 38589 | 1245 |
|  | 1981 | 7208 | 233 | 13495 | 435 | 39696 | 1281 | 60399 | 1948 |
|  | 1982 | 5709 | 187 | 8301 | 268 | 8790 | 284 | 22881 | 738 |
|  | 1983 | 11616 | 375 | 12765 | 412 | 33092 | 1067 | 57473 | 1854 |
| Survey Period | 1978 | 27210 | 373 | 85993 | 1178 | 93638 | 1283 | 206840 | 2833 |
|  | 1979 | 41510 | 314 | 103421 | 783 | 134493 | 1019 | 279424 | 2117 |
|  | 1980 | 37773 | 317 | 72610 | 610 | 108989 | 916 | 219372 | 1843 |
|  | 1981 | 36933 | 330 | 89601 | 800 | 166144 | 1483 | 292678 | 2613 |
|  | 1982 | 20288 | 221 | 10043 | 1087 | 153011 | 1663 | 273342 | 2971 |
|  | 1983 | 33813 | 275 | 93632 | 761 | 158915 | 1292 | 286360 | 2328 |

[1] Effort estimated in rod-hours; taken from Reid (1984b).

Table 3.2.3-3. Distribution of estimated angling effort (EAE) and mean daily effort (MDE) by day-type on the summer sport fishery on Long Point Bay, 1979-1983.[1]

|  | Weekday |  | Weekend |  |
|---|---|---|---|---|
| Year | EAE | MDE | EAE | MDE |
| 1979 | 99582 | 1158 | 179844 | 4861 |
| 1980 | 75511 | 921 | 143861 | 3888 |
| 1981 | 115691 | 1502 | 176897 | 5054 |
| 1982 | 85830 | 1341 | 187512 | 6697 |
| 1983 | 77290 | 909 | 209071 | 5502 |

[1] Effort estimated in rod-hours; taken from Reid (1984 b).

Table 3.2.3-4. Species composition of the sport fish catch in the summer boat fishery on Long Point Bay, 1978 - 1983.[1]

| | 1978 | | | 1979 | | | 1980 | | | 1981 | | | 1982 | | | 1983 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | C | % C | % H | C | % C | % H | C | % C | % H | C | % C | % H | C | % C | % H | C | % C | % H |
| Yellow perch | 104156 | 34 | 53 | 300048 | 43 | 43 | 247494 | 44 | 40 | 248153 | 40 | 41 | 159292 | 28 | 47 | 182704 | 28 | 40 |
| Smallmouth bass | 50190 | 16 | 83 | 79572 | 12 | 88 | 56226 | 10 | 84 | 63730 | 10 | 88 | 89301 | 16 | 82 | 90052 | 14 | 74 |
| Largemouth bass | 3467 | 1 | 76 | 3872 | <1 | 61 | 6285 | 1 | 65 | 11168 | 2 | 67 | 8900 | 2 | 42 | 14754 | 2 | 46 |
| Northern pike | 2782 | <1 | 56 | 7445 | 1 | 39 | 2661 | <1 | 78 | 7024 | 1 | 50 | 3979 | <1 | 45 | 4547 | <1 | 42 |
| Rock bass | 107101 | 35 | 35 | 248106 | 36 | 26 | 202095 | 36 | 26 | 221832 | 36 | 18 | 251600 | 44 | 18 | 245860 | 38 | 17 |
| Freshwater drum | 28591 | 9 | 18 | 32677 | 5 | 10 | 26089 | 5 | 11 | 37149 | 6 | 8 | 40486 | 7 | 9 | 52094 | 8 | 7 |
| Pumpkinseed | | | | | | | | | | | | | 13245 | 2 | 23 | 41940 | 7 | 10 |
| Bluegill | | | | | | | | | | | | | 2113 | <1 | 16 | 2289 | <1 | 37 |
| Crappie[2] | | | | 544 | <1 | 38 | 1584 | <1 | 60 | 1399 | <1 | 29 | 2700 | <1 | 22 | 3735 | <1 | 31 |
| Sunfish[3] | | | | 18425 | 3 | 16 | 22461 | 4 | 16 | 28919 | 5 | 6 | | | | | | |
| Panfish[4] | 6602 | 2 | 27 | | | | | | | | | | | | | | | |
| Bowfin | | | | 351 | <1 | 0 | 106 | <1 | 0 | 326 | <1 | 15 | 299 | <1 | 5 | 92 | <1 | 21 |
| Bullheads | | | | 349 | <1 | | | | | | | | 461 | <1 | 0 | 501 | <1 | 18 |
| White bass | | | | 165 | <1 | 52 | 108 | <1 | 100 | 30 | <1 | 0 | 51 | <1 | 0 | 2838 | <1 | 47 |
| Suckers | | | | 124 | <1 | 74 | | | | | | | | | | | | |
| American eel | | | | 47 | <1 | 100 | | | | | | | | | | | | |
| Catfish | | | | | | | 170 | <1 | 56 | 121 | <1 | 0 | | | | 84 | <1 | 19 |
| Carp | | | | | | | 18 | <1 | 0 | | | | | | | 51 | <1 | 0 |
| Walleye | | | | | | | | | | | | | | | | | | |
| Mooneye | | | | | | | | | | | | | | | | 91 | <1 | 100 |
| Other[5] | 1685 | <1 | 73 | | | | | | | | | | | | | | | |
| Total | 304574 | 100 | 48 | 691725 | 100 | 40 | 565297 | 100 | 38 | 619851 | 100 | 34 | 572427 | 100 | 36 | 641632 | 100 | 32 |

[1] C = Total estimated catch (in number); % C = percent of total catch; % H = percent of catch harvested.

[2] Crappie = black and white crappies.

[3] Sunfish = bluegill and pumpkinseed.

[4] Panfish = bluegill, pumpkinseed, and black and white crappie.

[5] Other = bowfin, catfish, bullheads and white bass.

Table 3.2.3-5. Percentage of total angling effort (rod-hours) exerted by species anglers on selected species in the summer sport fishery on Long Point Bay, 1979-1983.[1]

| Species Sought | 1979 | 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|---|
| Smallmouth bass | 62 | 59 | 69 | 84 | 59 |
| Yellow perch | 18 | 20 | 18 | 38 | 25 |
| Rock bass | 5 | 6 | 9 | 21 | 10 |
| Largemouth bass | 3 | 5 | 9 | 7 | 8 |
| Northern pike | 5 | 4 | 5 | 4 | 4 |

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[1] Data taken from Reid (1984b).

Table 3.2.3-6. Catch per unit of effort (CUE) of the principal species in the summer sport fishery on Long Point Bay by area and by month, 1978-1983.

| Year | CUE Type[1] | Area |  |  | Month |  |  | Survey Period |
|---|---|---|---|---|---|---|---|---|
|  |  | 1 | 2 | 3 | May-June | July | Aug. |  |
|  |  |  |  | **Yellow perch** |  |  |  |  |
| 1978 | all angler | 1.07 | 0.35 | 0.44 | 2.97 | 0.45 | 0.60 | 0.50 |
|  | spp. angler |  |  |  |  |  |  |  |
| 1979[2] | all angler | 1.75 | 1.09 | 1.12 | 1.43 | 0.83 | 1.48 | 1.24 |
|  | spp. angler | 2.69 | 3.20 | 3.00 | 1.99 | 2.66 | 2.91 | 2.94 |
| 1980 | all angler | 1.56 | 1.39 | 0.99 | 0.91 | 0.91 | 2.30 | 1.26 |
|  | spp. angler | 2.47 | 4.23 | 2.93 | 1.34 | 3.93 | 5.59 | 3.24 |
| 1981 | all angler | 1.46 | 0.80 | 0.70 | 1.49 | 0.61 | 1.18 | 0.87 |
|  | spp. angler | 3.28 | 1.89 | 2.20 | 2.07 | 1.93 | 3.32 | 2.29 |
| 1982 | all angler | 1.70 | 0.65 | 0.52 | 0.54 | 0.50 | 2.14 | 0.74 |
|  | spp. angler | 2.39 | 1.60 | 0.92 | 0.88 | 1.02 | 3.04 | 1.43 |
| 1983 | all angler | 1.22 | 0.76 | 0.67 | 0.83 | 0.53 | 1.35 | 0.78 |
|  | spp. angler | 2.35 | 2.19 | 1.84 | 1.33 | 1.71 | 2.77 | 2.05 |
|  |  |  |  | **Smallmouth bass** |  |  |  |  |
| 1978 | all angler | 0.11 | 0.27 | 0.24 | 0.00 | 0.29 | 0.13 | 0.24 |
|  | spp. angler |  |  |  |  |  |  |  |
| 1979 | all angler | 0.05 | 0.27 | 0.27 | 0.11 | 0.31 | 0.13 | 0.23 |
|  | spp. angler | 0.15 | 0.36 | 0.39 |  | 0.38 | 0.26 | 0.35 |
| 1980 | all angler | 0.06 | 0.27 | 0.24 | 0.08 | 0.29 | 0.13 | 0.21 |
|  | spp. angler | 0.16 | 0.40 | 0.33 |  | 0.36 | 0.26 | 0.33 |
| 1981 | all angler | 0.05 | 0.21 | 0.26 | 0.16 | 0.23 | 0.17 | 0.21 |
|  | spp. angler | 0.15 | 0.24 | 0.31 |  | 0.29 | 0.24 | 0.28 |
| 1982 | all angler | 0.06 | 0.30 | 0.34 | 0.25 | 0.32 | 0.07 | 0.28 |
|  | spp. angler | 0.17 | 0.34 | 0.38 | 0.58 | 0.36 | 0.18 | 0.35 |
| 1983 | all angler | 0.05 | 0.30 | 0.35 | 0.13 | 0.34 | 0.23 | 0.29 |
|  | spp. angler | 0.11 | 0.43 | 0.49 |  | 0.45 | 0.47 | 0.45 |
|  |  |  |  | **Largemouth bass** |  |  |  |  |
| 1978 | all angler | 0.00 | 0.01 | 0.02 | 0.00 | 0.01 | 0.01 | 0.01 |
|  | spp. angler |  |  |  |  |  |  |  |
| 1979 | all angler | 0.05 | 0.01 | 0.01 | 0.03 | 0.02 | 0.02 | 0.02 |
|  | spp. angler | 0.48 | 0.25 | 0.18 |  | 0.47 | 0.25 | 0.34 |
| 1980 | all angler | 0.05 | 0.02 | 0.02 | 0.02 | 0.03 | 0.02 | 0.03 |
|  | spp. angler | 0.23 | 0.22 | 0.42 | 0.00[3] | 0.36 | 0.15 | 0.26 |
| 1981 | all angler | 0.15 | 0.04 | 0.01 | 0.04 | 0.05 | 0.04 | 0.05 |
|  | spp. angler | 0.33 | 0.31 | 0.13 | 0.24[3] | 0.28 | 0.29 | 0.28 |
| 1982 | all angler | 0.10 | 0.02 | 0.02 | 0.04 | 0.02 | 0.08 | 0.03 |
|  | spp. angler | 0.35 | 0.30 | 0.26 | 0.29 | 0.33 | 0.29 | 0.31 |
| 1983 | all angler | 0.20 | 0.04 | 0.02 | 0.03 | 0.05 | 0.06 | 0.05 |
|  | spp. angler | 0.64 | 0.48 | 0.22 |  | 0.58 | 0.37 | 0.50 |

Table 3.2.3-6. con't ....

| Year | CUE Type | Area |  |  | Month |  |  | Survey Period |
|---|---|---|---|---|---|---|---|---|
|  |  | 1 | 2 | 3 | May-June | July | Aug. |  |
|  |  | **Northern pike** |  |  |  |  |  |  |
| 1978 | all angler | 0.01 | 0.01 | 0.02 | 0.00 | 0.01 | 0.01 | 0.01 |
|  | spp. angler |  |  |  |  |  |  |  |
| 1979 | all angler | 0.03 | 0.01 | 0.04 | 0.04 | 0.02 | 0.02 | 0.02 |
|  | spp. angler | 0.21 | 0.09 | 0.16 | 0.11 | 0.28 | 0.12 | 0.16 |
| 1980 | all angler | 0.01 | 0.01 | 0.02 | 0.05 | 0.00 | 0.01 | 0.01 |
|  | spp. angler | 0.02 | 0.15 | 0.23 | 0.21 | 0.04 | 0.00 | 0.17 |
| 1981 | all angler | 0.01 | 0.01 | 0.03 | 0.10 | 0.01 | 0.01 | 0.02 |
|  | spp. angler | 0.06 | 0.21 | 0.74 | 0.50 | 0.10 | 0.25 | 0.33 |
| 1982 | all angler | 0.01 | 0.02 | 0.01 | 0.07 | 0.01 | 0.01 | 0.01 |
|  | spp angler | 0.11 | 0.16 | 0.24 | 0.23 | 0.17 | 0.20 | 0.19 |
| 1983 | all angler | 0.02 | 0.01 | 0.01 | 0.07 | 0.01 | 0.01 | 0.02 |
|  | spp. angler | 0.24 | 0.19 | 0.22 | 0.28 | 0.06 | 0.23 | 0.22 |
|  |  | **Rock bass** |  |  |  |  |  |  |
| 1978 | all angler | 0.55 | 0.42 | 0.58 | 1.10 | 0.62 | 0.19 | 0.49 |
|  | spp. angler |  |  |  |  |  |  |  |
| 1979 | all angler | 0.55 | 0.62 | 0.71 | 0.97 | 0.83 | 0.29 | 0.64 |
|  | spp. angler | 1.15 | 1.85 | 0.99 | 1.28 | 1.29 |  | 1.28 |
| 1980 | all angler | 0.68 | 0.80 | 0.89 | 0.96 | 0.99 | 0.31 | 0.81 |
|  | spp. angler | 1.90 | 2.19 | 1.35 | 1.72 | 1.76 |  | 1.73 |
| 1981 | all angler | 0.43 | 0.85 | 0.63 | 1.38 | 0.70 | 0.25 | 0.67 |
|  | spp. angler | 1.63 | 2.29 | 1.44 | 2.05[3] | 1.72 | 1.00[3] | 1.91 |
| 1982 | all angler | 0.45 | 0.97 | 0.92 | 1.02 | 0.90 | 0.62 | 0.87 |
|  | spp. angler | 1.07 | 1.30 | 1.26 | 1.42 | 1.14 | 1.60 | 1.24 |
| 1983 | all angler | 0.61 | 0.85 | 0.76 | 1.42 | 0.82 | 0.37 | 0.76 |
|  | spp. angler | 1.66 | 1.48 | 1.78 | 1.96 | 1.39 | 1.69 | 1.69 |

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[1] all angler CUE = observed catches of a species +
observed no. rod-hours fished by all anglers

species (spp.) angler CUE = observed catches of a species +
observed no. rod-hours fished by anglers seeking that species.

[2] The by-area CUE's include catch and effort data for the first 9 days in September (approximately 92 boat party interviews).

[3] CUE derived from interviews of three or fewer boat parties.

Table 3.2.3-7. Mean TL at age (cm) of the principal species harvested in the summer sport fishery on Long Point Bay, 1971-1983.[1]

| Year | Statistic | AGE |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  | II | III | IV | V | VI | VII | VIII | IX | X |
|  |  | **Smallmouth bass** |  |  |  |  |  |  |  |  |
| 1971 | Mean |  | 22.3 | 24.4 |  |  |  |  |  |  |
|  | SD |  |  |  |  |  |  |  |  |  |
|  | N |  | 46 | 7 |  |  |  |  |  |  |
| 1972 | Mean | 17.8 | 22.3 | 27.0 | 30.1 |  |  |  |  |  |
|  | SD |  |  |  |  |  |  |  |  |  |
|  | N | 24 | 78 | 39 | 5 |  |  |  |  |  |
| 1979 | Mean | 29.0 | 25.0 | 29.3 | 32.7 | 35.7 | 42.3 | 35.0 |  |  |
|  | SD |  | 3.8 | 2.9 | 3.8 | 3.0 | 2.9 | 6.3 |  |  |
|  | N | 1 | 46 | 56 | 39 | 26 | 6 | 4 |  |  |
| 1981 | Mean | 23.0 | 26.8 | 30.0 | 33.9 | 35.5 | 41.9 | 45.0 | 48.0 |  |
|  | SD |  | 2.7 | 3.0 | 3.9 | 2.1 | 5.4 | 5.8 | 2.8 |  |
|  | N | 1 | 22 | 61 | 21 | 2 | 7 | 3 | 2 |  |
| 1982 | Mean | 22.0 | 26.3 | 29.8 | 35.1 | 38.2 | 38.4 |  | 44.7 | 44.5 |
|  | SD | 1.7 | 1.9 | 2.3 | 2.6 | 1.4 |  |  |  |  |
|  | N | 17 | 10 | 10 | 14 | 5 | 1 |  | 1 | 1 |
| 1983 | Mean | 22.1 | 26.3 | 30.4 | 34.4 | 33.2 | 39.8 |  | 46.0 |  |
|  | SD | 1.5 | 2.0 | 1.9 | 2.1 | 5.2 | 0.5 |  |  |  |
|  | N | 6 | 95 | 28 | 21 | 8 | 2 |  | I |  |
|  |  | **Largemouth bass** |  |  |  |  |  |  |  |  |
| 1982 | Mean |  |  | 36.4 | 39.9 | 42.4 |  | 44.5 | 45.8 | 47.4 |
|  | SD |  |  | 0.3 | 1.1 | 1.5 |  | 1.5 | 0.6 |  |
|  | N |  |  | 2 | 5 | 4 |  | 4 | 2 | 1 |
| 1983 | Mean | 23.8 | 29.4 | 32.2 | 35.4 | 37.8 |  |  |  |  |
|  | SD | 1.3 | 1.5 | 1.3 | 1.5 | 2.3 |  |  |  |  |
|  | N | 10 | 16 | 10 | 15 | 2 |  |  |  |  |
|  |  | **Yellow perch** |  |  |  |  |  |  |  |  |
| 1982 | Mean | 16.4 | 15.8 | 18.1 | 18.9 |  | 33.0 |  |  |  |
|  | SD |  | 1.4 | 1.5 | 1.5 |  |  |  |  |  |
|  | N | 1 | 40 | 27 | 10 |  | 1 |  |  |  |
| 1983 | Mean | 15.8 | 17.0 | 18.7 | 20.1 | 22.3 | 25.5 | 28.8 |  |  |
|  | SD | 0.5 | 1.2 | 1.7 | 1.6 | 2.0 |  |  |  |  |
|  | N | 4 | 48 | 69 | 33 | 9 | 1 | 1 |  |  |
|  |  | **Rock bass** |  |  |  |  |  |  |  |  |
| 1982 | Mean |  |  | 16.6 | 19.5 | 19.6 | 24.4 |  |  |  |
|  | SD |  |  | 3.5 | 1.2 | 19.6 | 24.4 |  |  |  |
|  | N |  |  | 2 | 28 | 4 | 1 |  |  |  |
| 1983 | Mean |  | 16.6 | 18.3 | 19.9 | 21.9 | 23.7 | 26.0 | 26.7 | 31.0 |
|  | SD |  |  | 1.0 | 3.8 | 3.1 | 1.5 | 0.5 | 2.0 |  |
|  | N |  | 1 | 14 | 51 | 58 | 7 | 2 | 3 | 1 |
|  |  | **Northern pike** |  |  |  |  |  |  |  |  |
| 1983 | Mean | 46.3 | 50.1 | 57.7 | 68.3 | 78.2 |  |  |  |  |
|  | SD |  | 4.1 | 5.3 | 4.7 | 9.0 |  |  |  |  |
|  | N | 1 | 4 | 13 | 3 | 2 |  |  |  |  |

[1] Data taken from Reid (1984b).

Table 3.2.3-8. Periods of commercial fish hut operation and creel census sampling in the winter ice fishery at St. Williams, Inner Bay, 1972-1983.[1]

| Year | Commercial Huts | Creel Census | No. of Parties Interviewed |
|---|---|---|---|
| 1972 | Jan 26 - Mar 16 | Feb 1 - Mar 12 | 505 |
| 1973 | Jan 12 - Jan 19;<br>Feb 1 - Mar 4 | Jan 17 - Mar 3 | 284 |
| 1974 | Jan 12 - Jan 21;<br>Feb 5 - Mar 3 | Jan 18 - Mar 3 | 245 |
| 1975 | Feb 6 - Feb 16 | Jan 23 - Feb 16 | 109 |
| 1976 | Jan 1 - Feb 16 | Jan 18 - Feb 13 | 172 |
| 1977 | Dec 26 - Mar 7 | Jan 15 - Feb 21 | 104 |
| 1978 | Jan 1 - Mar 12 | Jan 5 - Mar 11 | 421 |
| 1979 | Jan 6 - Mar 4 | Jan 9 - Mar 4 | 419 |
| 1980 | Jan 26 - Feb 23 | Jan 19 - Feb 28 | 376 |
| 1981 | Dec 26 - Feb 18 | | 0 |
| 1982 | Jan 16 - Mar 11 | Feb 5 - Mar 14 | 290 |
| 1983 | Jan 21 - Jan 23 | | 0 |

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[1] Data for 1972-1980 are from Sztramko and Paine (1984) and Hamley *et al.* (1981).

Table 3.2.3-9. Estimated total fishing effort and harvest of the principal species in the winter ice fishery on Inner Bay, 1978-1982.

| | | No. Harvested | | | | |
|---|---|---|---|---|---|---|
| Year | Effort (rod-hours) | Yellow perch | Northern Pike | Rainbow Smelt | Other | Total |
| 1978 | 109000 | 121000 | 270 | 5500 | 80 | 126850 |
| 1979 | 126900 | 314600 | 160 | 20400 | 280 | 335440 |
| 1980 | 47300 | 265000 | 240 | 18700 | 260 | 284200 |
| 1982 | 68700 | 285800 | 90 | 0 | 0 | 285890 |

Table 3.2.3-10. Total estimated effort, catch, and catch per unit of effort of selected species in sport fisheries in Canadian waters of Lake Erie, 1978-1983.

|  |  | SPECIES CATCH AND CUE[1] BY SPORT FISHERY |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Yellow Perch |  | Rock Bass |  | Smallmouth Bass |  | Largemouth Bass |  | Northern Pike |  | White Bass |  | Freshwater Drum |  |  |
| Year | Total Effort (Rod-Hours) | C | CUE | C | CUE | C | CUE | C | CUE | C | CUE | C | CUE | C | CUE | Data Source |
|  |  | NANTICOKE THERMAL GENERATING STATION |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1982 | 15461 | 3905 | 0.642[2] | 3626 | 0.932[2] | 8863 | 0.784[2] | 0 |  | 0 |  | 51493 | 4.820[2] | 3665 | 1.875[2] | Witzel 1984 |
| 1983 | 15349 | 2692 | 0.457 | 2183 |  | 5442 | 0.589 | 62 |  | 0 |  | 54858 | 3.510 | 2861 |  | Witzel 1985 a |
|  |  | LONG POINT BAY |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1978 | 206840 | 104156 | 0.50[3] | 107101 | 0.49[3] | 50190 | 0.24[3] | 3467 | 0.01[3] | 2782 | 0.01[3] | 0 |  | 28591 |  | Reid 1984 a |
| 1979 | 279424 | 300048 | 2.94 | 248106 | 1.28 | 79572 | 0.35 | 3872 | 0.34 | 7445 | 0.16 | 165 |  | 32677 |  | Powell 1980 |
| 1980 | 219372 | 247494 | 3.24 | 202095 | 1.73 | 56226 | 0.33 | 6285 | 0.26 | 2661 | 0.17 | 108 |  | 26089 |  | Owen 1980 |
| 1981 | 292678 | 248153 | 2.29 | 221832 | 1.91 | 63730 | 0.28 | 11168 | 0.28 | 7024 | 0.33 | 30 |  | 37149 |  | Miller 1983 |
| 1982 | 273342 | 159292 | 1.43 | 251600 | 1.24 | 89301 | 0.35 | 8900 | 0.31 | 3979 | 0.19 | 51 |  | 40486 |  | Reid 1984 a |
| 1983 | 286360 | 182704 | 2.05 | 245860 | 1.69 | 90052 | 0.45 | 14754 | 0.50 | 4547 | 0.22 | 2838 |  | 52094 |  | Reid 1984 b |
|  |  | RONDEAU BAY |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1978 | 58603 | 12246 | 0.889 | 1180 | 0.199 | 129 | 0.044 | 3704 | 0.108 | 2343 | 0.133 | 371 | 0.439 | 2567 | 0.221 | Dunlop and Sztramko 1979 |
| 1979 | 51658 | 22762 | 1.240 | 1682 | 0.260 | 228 | 0.091 | 3727 | 0.174 | 2004 | 0.176 | 166 | 0.200[4] | 2222 | 0.145 | Sztramko 1980 a |
| 1980 | 38970 | 24185 | 1.132 | 456 | 0.105 | 93 | 0.212 | 2717 | 0.170 | 1636 | 0.160 | 1196 | 0.210 | 1467 | 0.357 | Witzel 1981 a |
| 1981 | 29523 | 13661 | 0.782 | 985 | 0.313 | 137 | 0.044 | 1426 | 0.143 | 521 | 0.094 | 0 |  | 868 | 0.248 | Hyatt 1982 a |
| 1982 | 32852 | 33716 | 2.189 | 1260 | 0.710 | 104 | 0.006 | 1679 | 0.166 | 711 | 0.087 | 4879 | 0.545 | 3837 | 0.000[4] | Hyatt 1983 a |
| 1983 | 32892 | 20638 | 1.296 | 185 | 0.113 | 313 |  | 1518 | 0.228 | 295 | 0.113 | 7010 | 1.041 | 4793 | 0.590 | Battson 1985 |
|  |  | WESTERN BASIN |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1978 | 146098 | 11045 |  | 184 |  | 7628 | 0.247 | 0 |  | 0 |  | 1898 |  | 97798 |  | Sztramko 1979 a |
| 1979 | 95555 | 5679 |  | 55 |  | 4250 | 0.768 | 815 | 0.619 | 0 |  | 3450 | 0.387[4] | 72694 |  | Sztramko 1980 b |
| 1980 | 91237 | 8628 | 0.212 | 33 | 0.071[4] | 4833 | 0.392 | 0 |  | 0 |  | 1213 | 1.103 | 76905 | 0.951 | Witzel 1981 b |
| 1981 | 136398 | 4770 | 0.165 | 154 | 0.039[4] | 6206 | 0.289 | 0 |  | 0 |  | 1666 | 0.175 | 58680 | 0.485 | Hyatt 1982 b |
| 1982 | 106566 | 4398 | 0.152 | 76 | 0.114[4] | 7955 | 0.307 | 0 |  | 0 |  | 3467 | 0.276 | 61741 | 0.373 | Hyatt 1983 b |
| 1983 | 116649 | 190 | 0.250[4] | 327 |  | 20784 | 0.323 | 0 | 0.000[4] | 0 |  | 3315 | 0.163 | 38233 | 0.417[4] | Hyatt 1984 |
|  |  | DETROIT RIVER |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1978 | 122979 | 13470 | 0.904 | 9504 | 0.308 | 450 | 0.154 | 203 | 0.000[4] | 81 | 0.069 | 16213 | 0.482 | 23328 | 0.303 | Sztramko 1979 b |
| 1979 | 144458 | 16764 | 0.960 | 9124 | 0.279 | 566 | 0.500 | 42 | 0.195 | 122 | 0.264 | 107982 | 1.297 | 22572 | 0.381 | Sztramko 1980 c |
| 1980 | 143295 | 18778 | 0.663 | 9031 | 0.309 | 1120 | 0.146 | 120 | 1.000[4] | 171 | 0.232 | 109068 | 1.920 | 19583 | 0.278 | Witzel 1981 c |

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[1] Unless otherwise noted, CUE's are unweighted estimates derived from observed catch and effort (rod-hours) data of anglers seeking a particular species.

[2] Unweighted CUE of species anglers (footnote 1) fishing in the NTGS discharge channel (excludes plume catch and effort data).

[3] Unweighted CUE derived from observed catch and effort (rod-hours) data of all anglers.

[4] CUE estimated from observed catch and effort data of two or fewer angling parties.

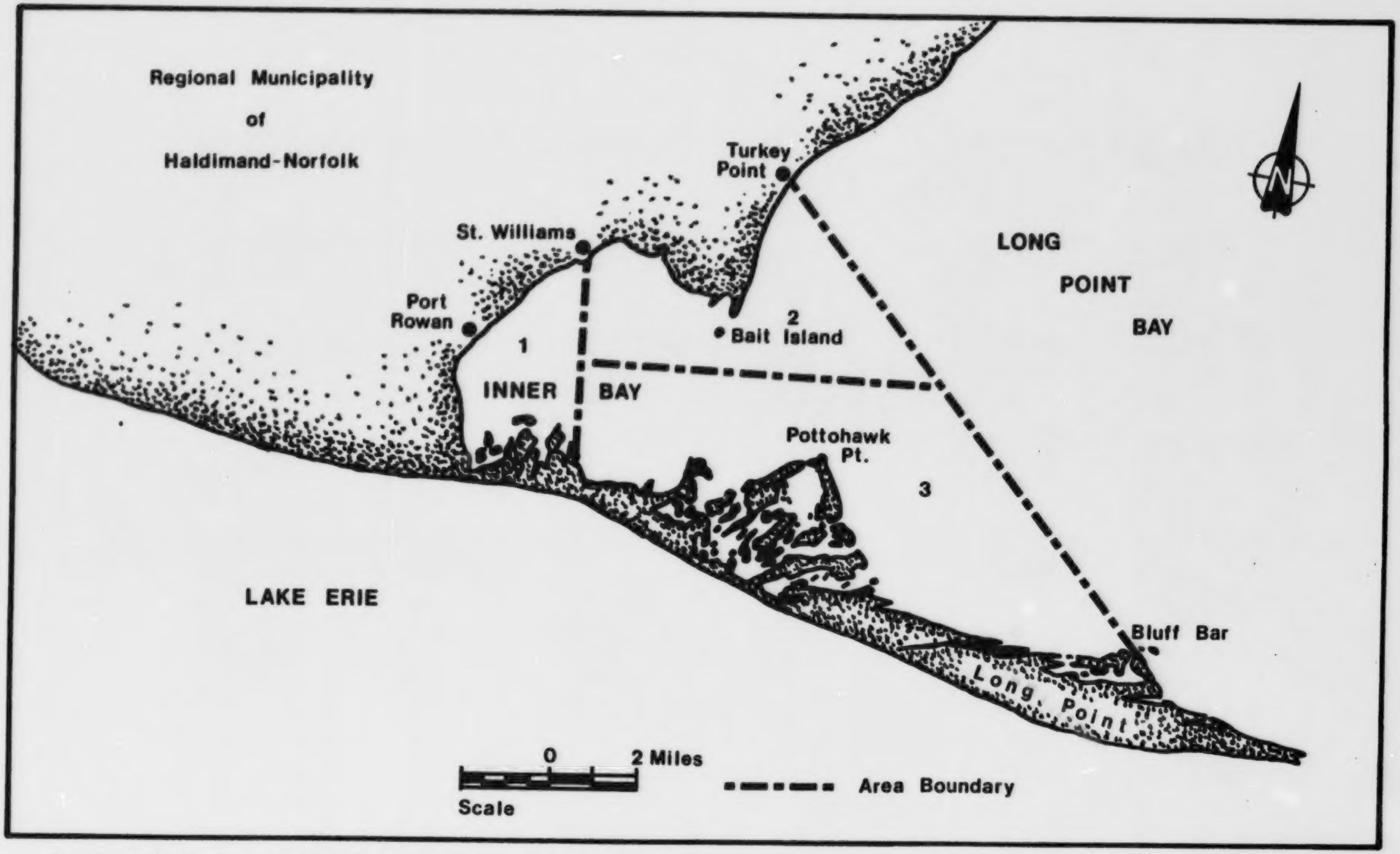
Regional Municipality
of
Haldimand-Norfolk
Turkey Point
St. Williams
Port Rowan
LONG
POINT
BAY
2
Bait Island
1
INNER
BAY
Pottohawk Pt.
3
LAKE ERIE
Bluff Bar
Long Point
N
0
2 Miles
Scale
Area Boundary

Figure 3.2.3-1. Long Point Bay creel census areas.

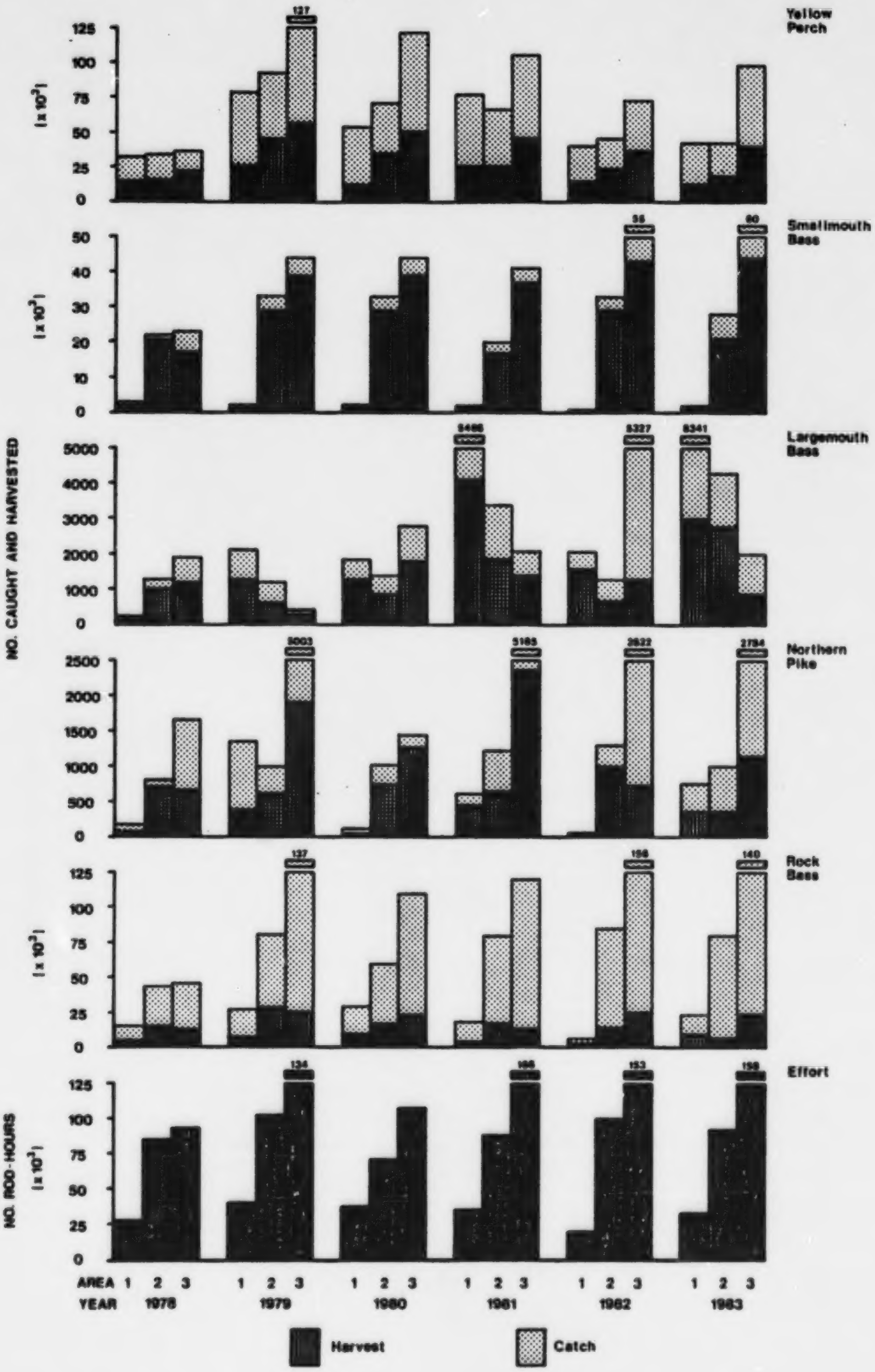

Figure 3.2.3-2. Estimated total catch and harvest of selected species and estimated total angling effort by area and year in the summer sport fishery on Long Point Bay, 1978-1983.

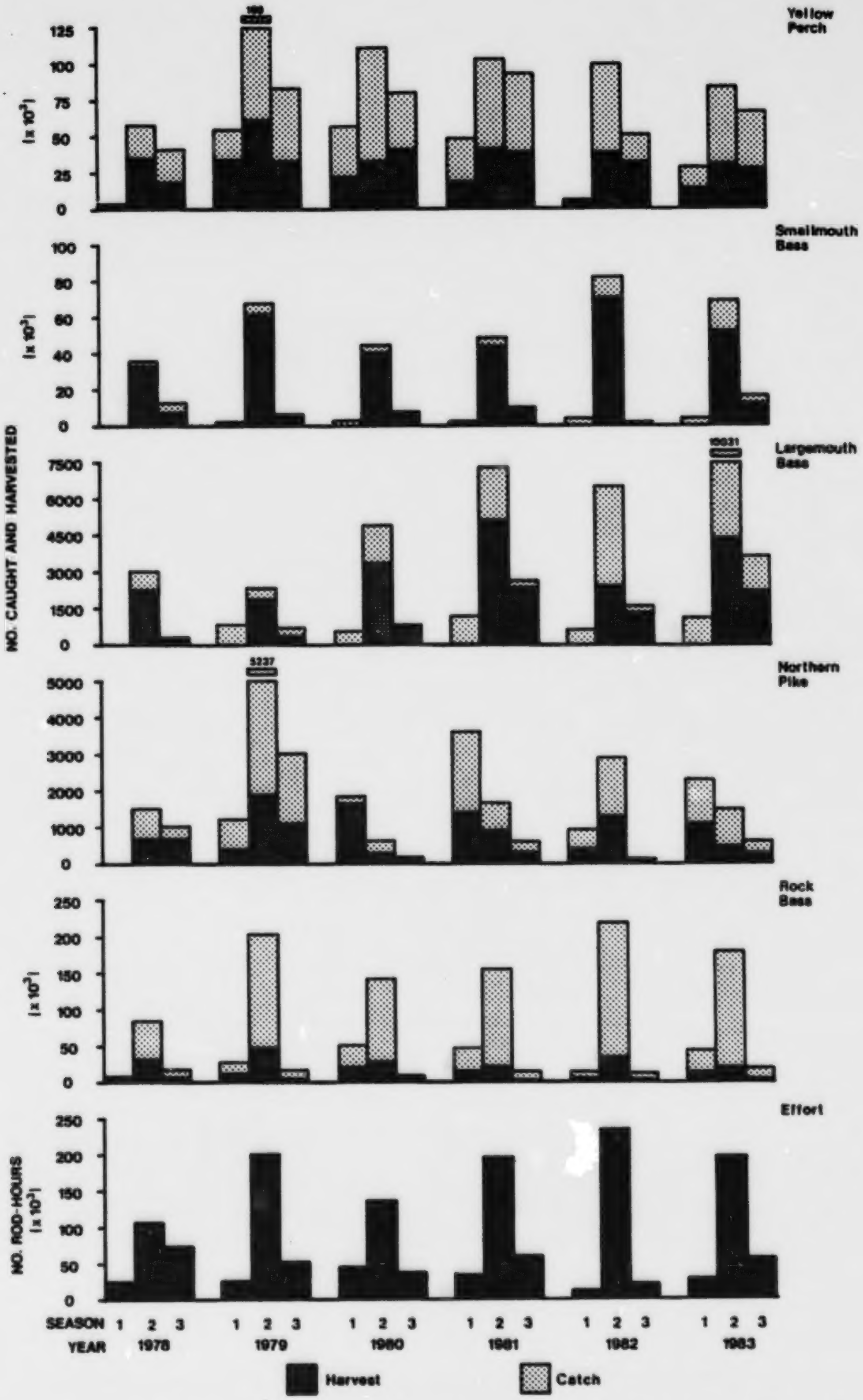

Figure 3.2.3-3. Estimated total catch and harvest of selected species and estimated total angling effort by season and year in the summer sport fishery on Long Point Bay, 1978-1983.

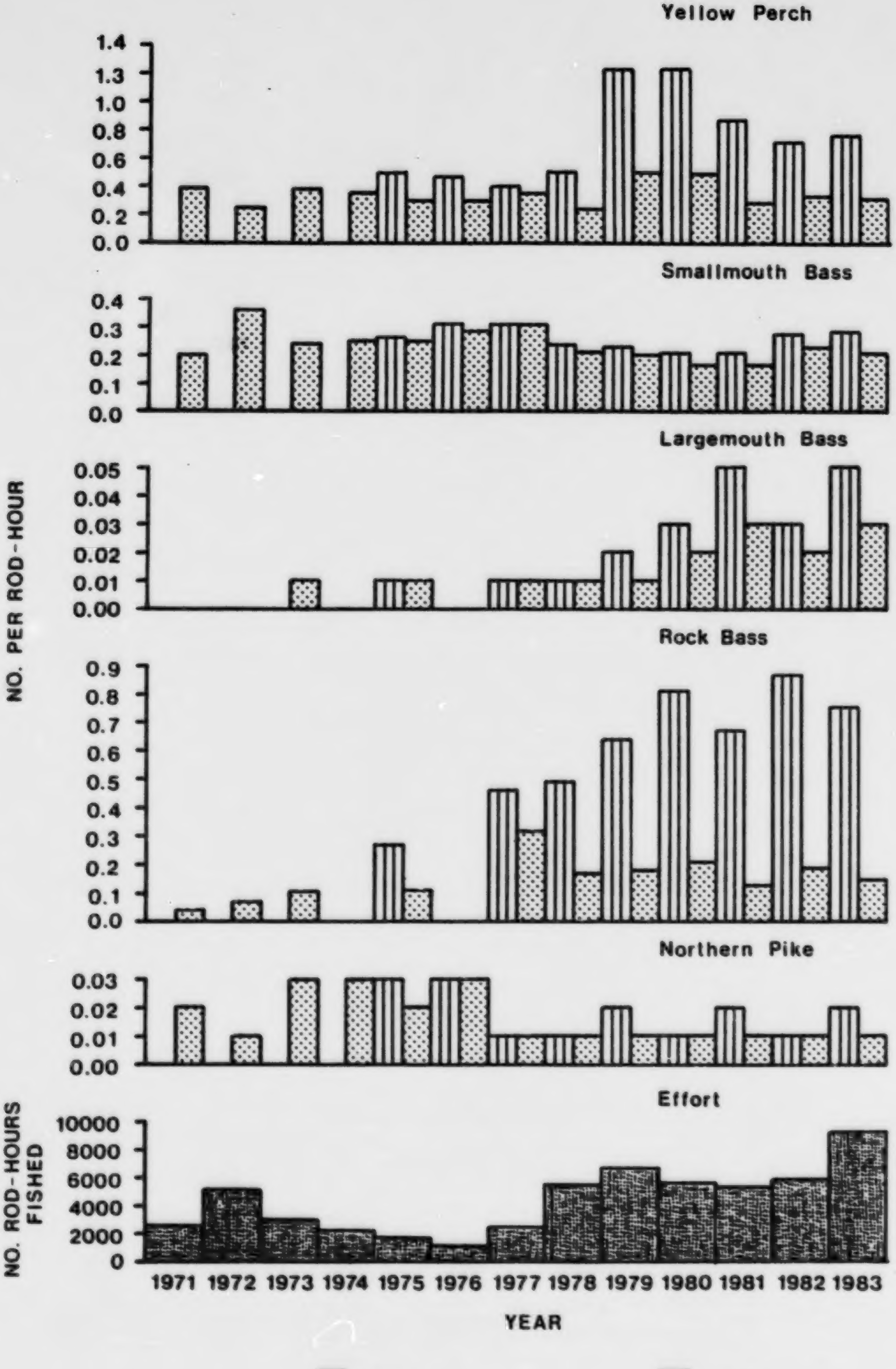

Figure 3.2.3-4. Catch per unit effort (CUE) and harvest per unit effort (HUE) of selected species by all anglers in the summer sport fishery on Long Point Bay, 1971-1983. CUE's before 1975 were not determined.

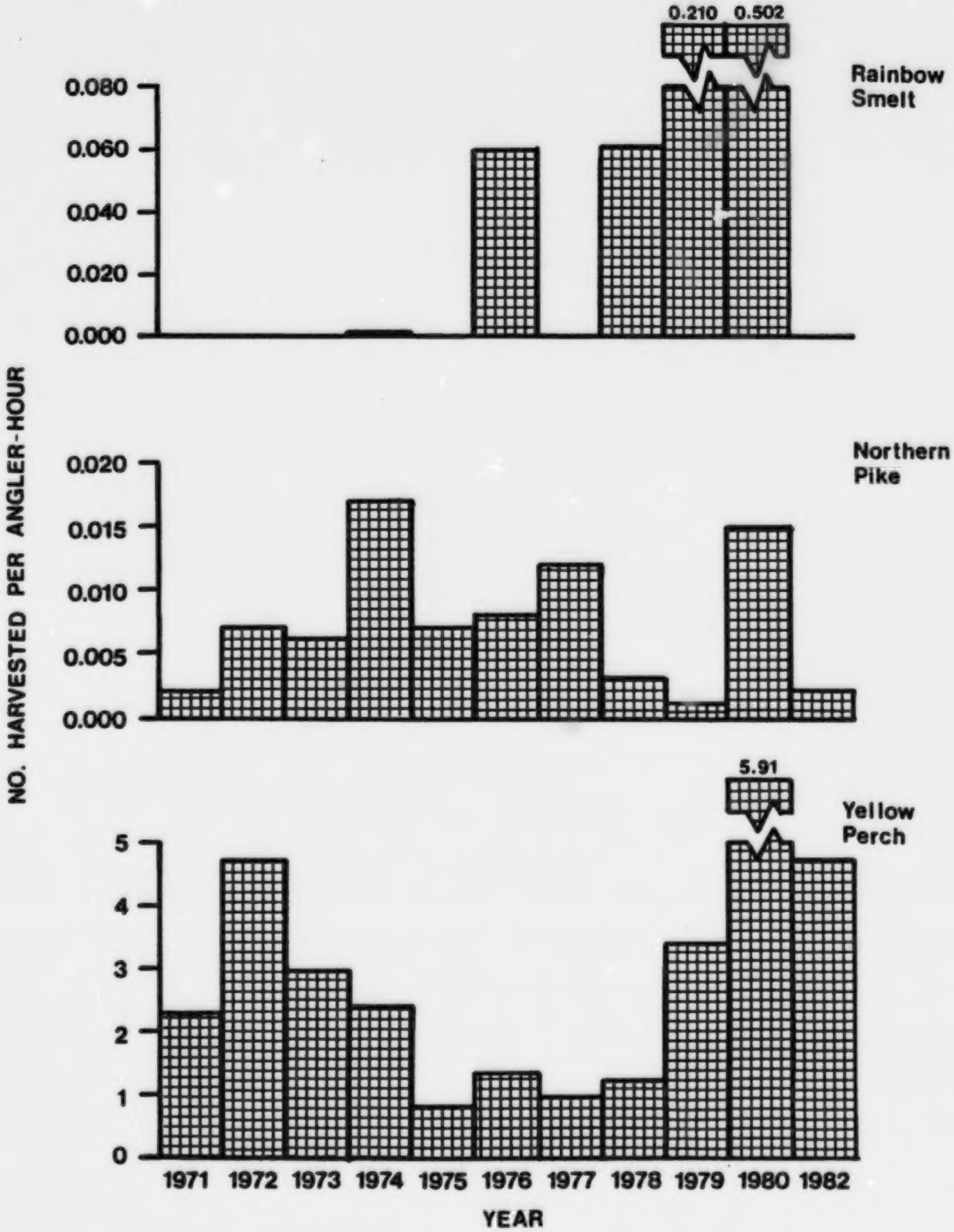

Figure 3.2.3-5. Harvest per unit of effort (all anglers) of selected species in the winter ice fishery on Inner Bay, 1971-1982.

## 3.2.4 Sport Fishing and the Effects of Warm Water Discharge on Angler Success Rates in the NTGS Outfall

### Introduction

Since 1972, power production at the Nanticoke Thermal Generating Station (NTGS) has increased to 48% of its annual gross design capacity with a corresponding increase in discharge of heated water (Figure 3.2.4-1). A substantial, but very localized sport fishery has developed on the NTGS outfall in recent years. In 1982 and 1983 the NFS sought to identify important information relating to management and to assessing the response of this fishery to industrial effects (Witzel 1984, 1985a). With the exception of a general user group survey in 1975 and 1976 (Chamberlain 1979), no previous creel census had been conducted on the NTGS outfall or vicinity.

The objectives of the 1982 and 1983 creel census surveys were as follows:

1. to quantify the spatial and temporal distributions of angler effort,
2. to estimate angler catch, harvest, and catch per unit of effort (CUE),
3. to define the age and length composition of selected species in the harvests, and
4. to determine residency status of anglers.

The attraction of fish to natural waters heated by power plants has been observed throughout North America (Landry and Strawn 1973, Marcy and Galvin 1973, Moore _et_ _al_. 1973, Neill and Magnuson 1974). In most cases, above-ambient temperature was regarded as the principal factor attracting fish to these areas. At the NTGS, fishing success also seemed to be related to levels of thermal discharge (from the observations of creel census clerks and reports by anglers). Supplementary analyses were undertaken, to determine the relative importance of temperature, flow and other environmental variables in attracting fish to the NTGS discharge channel.

## Methods

### A. Creel Census Survey

The creel census surveys in 1982 and 1983 were conducted eight and seven months, respectively, beginning the first week of April (Table 3.2.4-1). The surveys incorporated spatial (area) and temporal (season and day-type) stratification. The outfall was stratified into two areas, the discharge channel and plume (Figure 3.2.4-2). The discharge channel included all waters extending 244 m upstream from the mouth of the outfall to a boom stretched across the channel (approximately 0.9 ha). Anglers fished in the discharge channel despite a posted warning prohibiting the entry of boats. The plume arbitrarily was defined as the surface waters within a 1-km radius of the discharge channel outfall (between the compass headings of 68 and 204°). This area of approximately 120 ha was visible from an onshore vantage point on the west side of the discharge channel. The outfall was accessible to the general public only by boat, usually from Hoover's Marina and vicinity in Nanticoke Creek. In this report, the term NTGS "outfall" is used to describe the combined surface waters of the discharge channel and plume, whereas the term "discharge outfall" refers to the actual point that cooling water (condensor cooling plus tempering water) is discharged into Lake Erie (ie. boundary between the discharge channel and the plume).

Months were stratified into three seasons: spring (April 1 to the last Friday in June), summer (opening day of smallmouth bass season to September 22), and fall (September 23 to November 30 [1982] or October 31 [1983]). Days were stratified into two types: weekdays and weekends (including Canadian holidays). In 1982, days were also stratified into morning (sunrise to 1230 h) and afternoon (1231 h to sunset) periods. To make years comparable, the day-time stratification was not used in this report.

Creel census days were selected systematically with weekdays scheduled independently of weekend days. Every other weekday and at least every two in three weekend days were assigned a survey period. Discrete 1-hour census periods were assigned at random to each scheduled census day. In general, 1 hour was sufficient time to count and interview all boat parties in the outfall.

The 1982 and 1983 creel census surveys differed in one major respect. All scheduled surveys in 1982 during the spring and summer angling seasons were conducted from shore, whereas the fall angling season in 1982 and all seasons in 1983 were surveyed from a boat. This difference did not diminish the reliability of our angling effort estimates because boat (party) counts were accomplished with equal accuracy on shore as off shore. Reliable estimates of catch, harvest, and CUE for the plume area during the onshore survey (spring and summer 1982), however, were not possible because boat parties fishing in the plume could not be approached for interviews. To supplement scheduled creel information in 1982, surveys were conducted from a boat at unscheduled times, usually on weekdays when NFS trap nets or gill nets were sampled.

Offshore surveys were conducted from a 6.4-m steel boat (63.4-kw outboard) by a crew of two. During a census period the survey crew recorded the number of boat parties fishing and their boat locations. Boat parties were asked questions about their species preference, catch, fishing effort, and origin. Angler responses were coded on standard creel census forms. Scale samples, and length and weight measurements were collected from a representative number of the principal species harvested.

Analysis of census data was performed by an APL computer program developed by the Lake Erie Fisheries Assessment Unit (Petzold 1980). Observed daily estimates of catch, harvest, and effort were summed and expanded to derive estimates of the same for individual strata.

Effort was calculated in rod-hours and in angler-hours. The two measures differed only when some members of a boat party were not actively fishing or fished with more than one rod. Non-fishing members were considered as anglers because they had few alternative recreational activites in which to participate.

Rod-hours were considered to be a more precise measure of effort than angler-hours; therefore, rod-hours were used to derive catch and harvest estimates. Relative abundance of fish species was determined by calculating catch per unit of effort (CUE). The unweighted CUE reported in this study was equal to the actual total number of a species caught divided by the actual number of rod-hours expended in capturing that species. Unweighted CUE's were calculated for "species anglers" (anglers seeking a particular species) and for "all anglers" regardless of their species preference.

Despite the inclusion of unscheduled census information in the analysis of 1982 data (spring and summer angling season), some strata incorporating the plume lacked sufficient data. For these strata, catch, harvest, and CUE were approximated using methods described by Witzel (1984).

### B. Effects of Warm Water Effluent, Climate, and Wave Intensity on Angler CUE's of White Bass and Smallmouth Bass

Environmental data were supplied by government agencies and private industry. Ontario Hydro provided records of hourly water temperature (to nearest °C) and discharge flow (to nearest $m^3.sec^{-1}$), and daily net power production (to nearest MW) at the NTGS. The Ontario Ministry of the Environment provided wind speed (to nearest $m.sec^{-1}$), wind direction (to nearest degree), and air temperature (to nearest 0.1°C) data measured hourly at a 10-m tower in Jarvis, Ontario. Precipitation records were provided by Environment Canada; total accumulated precipitation was measured semi-daily at Texaco Canada, Nanticoke. Precipitation data were coded as follows: 0 = no precipitation, 1 = 1 to 5 mm, 2 = 6 to 10 mm, .......8 = 36 mm to 40 mm, and 9 = 41 mm or more.

Wind directions ranging from 181 - 360° were recoded to reflect onshore versus offshore winds; the highest value (180°) was assigned to winds blowing directly onshore (S to N) and the lowest (0°) to winds blowing directly offshore (N to S). The recoding procedure was as follows for wind directions > 180° : recoded wind direction = 360 - wind direction. Observed wave heights were coded as follows: 1 $\leq$ 0.33 m, 2 = 0.33 to < 0.66 m, 3 = 0.66 to < 1.00 m, 4 = 1.00 to < 1.33 m, 5 $\geq$ 1.33 m. In addition to observed wave height, an index of marine surface conditions (wave intensity index) was estimated by taking the product of wind speed and recoded wind direction (0 - 180°). Higher wave intensities resulted from onshore compared to offshore winds of the same speed.

Environmental data were coded for days or parts of days corresponding to each creel census period. For environmental variables measured hourly, a mean was taken of the 12 (wind speed and direction, wave intensity index, water temperatures, discharge flow) or 6 hourly (air temperature) readings preceeding and including the hour of creel census.

Unweighted all-angler CUE's of white bass and smallmouth bass were calculated for only the discharge channel. CUE's of all other species in the discharge channel and all species in the plume were not considered in the analyses because of insufficient data.

The amount of association between logged CUE's ($\log_{10} x + 0.01$) and environmental variables was determined by Pearson product-moment correlation analysis at a significance level of 5% or less ($P \leq 0.05$). Stepwise multiple regressions (maximum $R^2$ improvement) were applied to derive the best equations for predicting CUE's of white bass and smallmouth bass, and to explain the amount of variation in

CUE's due to one or more environmental effects. Correlations and regressions were performed by statistical programs contained in SAS (SAS Inst. Inc.).

## RESULTS

### A. Creel Census Surveys

Some 600 boat parties were interviewed during the spring, summer, and fall angling seasons on the NTGS outfall in 1982-1983. Anglers lived primarily (> 60%) in the Region of Haldimand-Norfolk and fished with a variety of live and artificial baits from stationary boats in parties of three or less (mean = 2.5) for an average of 3.4 hours per trip.

Anglers exerted approximately 15,500 rod-hours of effort each year on the NTGS outfall, mostly during spring and summer (Table 3.2.4-2). Less than 10% of total angling effort occurred in fall. In spring, anglers fished mostly in the discharge channel for white bass. In summer when smallmouth bass were in season, fishing pressure was higher in the plume than in the discharge channel (1982), or was distributed equally between the two areas (1983). Angling on the outfall was most dense in the lower sections of the discharge channel and in the plume within 100 m of the discharge outfall.

Total fishing pressure (rod-hours) in spring was greater on weekdays than on weekends, but the reverse was true in summer (Table 3.2.4-3). Average fishing intensity (No. rod-hours/day), however, was generally two to three times higher on weekends than on weekdays in all seasons.

Weather and lake conditions had a significant effect on day-to-day fishing activity. Daily boat counts were negatively correlated (P <

0.01; $220 < N < 300$) with wave height ($r = -0.462$), precipitation ($r = -0.187$), wind speed ($r = -0.452$), and wave intensity index ($r = -0.372$), but were positively correlated ($P < 0.0001$; $N = 268$) with air temperature ($r = 0.376$). Adverse weather occurred more frequently in spring and fall than in summer (Table 3.2.4-10).

Anglers caught almost 70,000 fish during the survey period each year in 1982 and 1983 (Table 3.2.4-4). Three-quarters or more of the total catch was kept. White bass comprised most (>70%) of the total catch, followed by smallmouth bass (8 - 12%), yellow perch (4 - 5%), rock bass (2 - 5%) and freshwater drum (4 - 5%). Ten other species were reported caught in 1983, but the combined catches of these fish amounted to only 1% of the total catch (Table 3.2.4-4).

White bass were the single most important species in the NTGS sport fishery in terms of effort (sought by > 55% of anglers), total catch (> 80%), and total harvest (> 85%) (Tables 3.2.4-4 and -5). Their dominance in the fishery was most apparent in spring when more than half of the annual total catch was taken, and at least three out of four fishing parties sought this species (Table 3.2.4-6). Fishing for white bass was better in the discharge channel than in the plume; white bass anglers in the discharge channel averaged 4.820 bass/rod-hour in 1982 and 3.852 bass/rod-hour in 1983 (Table 3.2.4-7). Success rate of white bass anglers was best during spring when average catches of 7 bass/rod-hour were observed (1982). White bass fishing worsened considerably through the angling season; even so, the seasonal average CUE's were higher for white bass than for any other species throughout the survey period.

The 1980 year class of white bass was prominent in the angler harvest as age II fish in 1982 (94% of total harvest) and as age III fish in 1983 (43% of total harvest) (Table 3.2.4-8). Age II bass dominated the sport harvest in both years. Mean TL of age II white bass was 254 mm ± SD = 22.0 in 1982 and 247 mm ± SD = 18.9 in 1983.

Open season of smallmouth bass fishing on Lake Erie began on the last Saturday in June. All anglers fishing on the NTGS outfall prior to opening day claimed not to have sought this species (Table 3.2.4-5); however, an estimated 1,800 or more smallmouth were caught and released during the closed season in 1982 and 1983 (Table 3.2.4-6). In spring most smallmouth bass were caught in the discharge channel when approximately 0.4 to 0.5 bass were caught per rod-hour (Table 3.2.4-7).

One-third or more of all boat parties sought smallmouth bass during open season (summer and fall) (Table 3.2.4-5). Almost two-thirds of the annual total catch of smallmouth bass was taken during the open season. Of these, some 50 - 60% were harvested (Table 3.2.4-6). Smallmouth bass fishing generally was best (highest CUE) in the fall (Table 3.2.4-7). Ages of harvested smallmouth bass ranged from 1 to 9 (Table 3.2.4-8).

### B. Effects of Warm Water Effluent, Climate, and Wave Intensity on Angler CUE's of White Bass and Smallmouth Bass

Angler CUE's of white bass and smallmouth bass in the NTGS discharge channel were more closely associated with water temperature (intake and outfall) than any other environmental variable examined (Table 3.2.4-9). Temperatures were more highly correlated with CUE's of white bass (maximum $r = 0.850$) than smallmouth bass (maximum $r = 0.427$). CUE-temperature correlations were highest in spring for both species. Temperature had a positive effect on angler catches in the spring and fall, but in summer had no effect or a negative one (Table 3.2.4-9).

Anglers usually began fishing regularly in the discharge channel the first week of May (Figures 3.2.4-3 and -4). Consistent catches of white bass and smallmouth bass did not begin until mid-May when lake (intake) temperatures ranged from 9 to 11°C, and outfall temperatures from 14 to 16°C. Outfall temperatures were warmer than lake temperatures by an average of 3 - 4°C, except in the summer and fall angling seasons of 1983 when the average temperature rise was 5 - 6° C (Table 3.2.4-10). Beginning July 1, 1983, Ontario Hydro reduced tempering of condensor cooling water. During the non-tempering period (summer and fall), outfall temperatures ranged from 11 to 33°C (mean = 24.3°C) and discharge flows were reduced well below normal tempering levels (1982 versus 1983 mean: 106.4 versus 77.0 $m^3 \cdot sec^{-1}$) despite an increase in power production (1982 versus 1983 daily mean: 1,329 versus 1,833 MW) over the same period (summer and fall) in 1982.

Discharge flow had a positive effect on angler CUE's, but the effect was insignificant ($P > 0.05$) in all seasons except spring (1982) for white bass ($r = 0.477$) (Table 3.2.4-9). Catches of white bass per unit of effort also were significantly correlated ($P \leq 0.05$) with air temperature (spring 1983: $r = 0.392$), precipitation (summer 1983: $r = 0.375$), and wave height (fall 1982: $r = 0.832$; summer 1983: $r = 0.357$). Other significant correlations of smallmouth bass CUE's were with precipitation (fall 1982: r = 0.572; summer 1983: r = 0.444) and air temperature (fall 1982: r = 0.554).

Water temperature data were highly ($P < 0.001$) intercorrelated (with other environmental variables), as were correlations of wave index with wind speed (r = 0.749; df = 265), wind direction (r = 0.683; df = 265), and wave height (r = 0.559; df =194) (Table 3.2.4-9). Station power production was highly correlated with outfall temperature (r = 0.456; df = 284), temperature rise (r = 0.838; df = 275), and discharge flow (r = 0.310; df = 286).

To minimize unwanted bias in linear regressions due to multicollinearity among independent variables, only variables which were not highly intercorrelated were selected. Those selected were outfall temperature, discharge flow, wave index, and precipitation. The best multiple regression equation of two to four independent variables was selected by a forward stepwise procedure (maximum $R^2$ improvement). Independent variables explaining < 1% of the variation in logged (base 10) angler CUE's were excluded from linear models.

With few exceptions, outfall temperature explained more of the variation in angler CUE's than did any other variable (Table 3.2.4-11). As much as 64% of the variation in white bass CUE's (Equation 1) and 32% of the variation in smallmouth bass CUE's (Equation 5) was explained by outfall temperature (Table 3.2.4-11).

Wave index explained 41% of the variablility in CUE's of smallmouth bass in the summer of 1982 (Equation 6) and discharge flow explained 21% of the smallmouth bass CUE variability in the summer of 1983 (Equation 8). When the variation of outfall temperature was accounted for first, the inclusion of other independent variables into regression models improved the multiple $R^2$ by as much as 16% (Equation 2). All multiple regression models except one (Equation 4) were significant ($P < 0.05$); collectively, the independent variables accounted for a significant portion of the variance of white bass and smallmouth bass CUE's (Table 3.2.4-11).

## Discussion

Total angling pressure on the thermal discharge of the Nanticoke Generating Station was similar to other sport fisheries in the Canadian waters of eastern Lake Erie (13,000-17,000 rod-hours annually), but was considerably smaller than the long established summer sport fisheries in Long Point Bay (280,000 rod-hours annually), Rondeau Bay (33,000 rod-hours annually), the Western Basin (110,000 rod-hours annually), and Detroit River (140,000 rod-hours annually) (Table 3.2.4-12). Effort density (total rod-hours/ha) was several times greater in the NTGS outfall than elsewhere in Lake Erie. In the discharge channel alone, angling pressure totalled over spring, summer, and fall was in excess of 9,000 rod-hours/ha. By comparison, effort density was only 52.5 rod-hours/ha in the Detroit River (1980 survey) and 65.0 rod-hours/ha in Gravelly Bay, Port Colborne (1980 survey).

The NTGS outfall was the only area along the north shore of Long Point Bay where anglers concentrated. Chamberlain (1976) observed only a few (N = 12) boat parties fishing west of the generating station during a 5-wk mid-summer period in 1975. Opportunities for catching yellow perch, rock bass, and smallmouth bass in the nearshore zone outside the influence of thermal discharge, however, would seem to be fair based on the relative abundance of these species in MNR trap nets (Section 3.2.1). Insufficient access points, susceptibility to weather, and fewer numbers and varieties of fish are possible explanations of why fishing pressure was light near Nanticoke (except in the discharge outfall) compared to western Long Point Bay (Section 3.2.3).

Fishing pressure on the NTGS outfall probably will increase as popularity of this fishery spreads. Angling may become particularly intense during spring as anglers prohibited from fishing in Long Point Bay (bass spawning sanctuary from mid-May to opening day of bass season), may seek alternate fishing opportunities elsewhere.

Although some anglers undoubtedly fish in the outfall over the cold months (November-March), the extent and nature of sport fishing during this period is not known, but is presumed to be negligible. Harsh weather, poor lake conditions, and restricted access are factors discouraging angling activities in the thermal discharge during winter. In contrast, extensive winter sport fisheries have developed on thermal discharges of several generating stations in more temperate climates in the eastern and southern United States (Elser 1965, Moore and Frisbie 1972, Moore et al. 1973, Landry and Strawn 1973, Marcy and Galvin 1973).

Anglers crowded into a small area of the thermal discharge thoughout the survey period because of excellent fishing success. Maximum fishing pressure in spring coincided with greatest white bass abundance (based on CUE's). Some 20,000-30,000 white bass were harvested annually in a 0.9 ha (> 22,000 white bass/ha) section of the discharge channel from mid-May to June. Harvest density of white bass during a comparable period (mid-May to June) in the Detroit River was only 37 bass/ha (Witzel 1981c).

Intense fishing for white bass in the discharge channel during spring (mid-May to June) coincided with the reproductive period of smallmouth bass and resulted in an incidental catch of several hundred smallmouth bass. Interference of the nest guarding activities by anglers may have increased egg and fry mortality of smallmouth bass in the discharge channel where predator (eg. white bass) density was high. Olmsted and Kilambi (1971) found that adult white bass fed partly on small Micropterus spp. during spring and summer. Dietary studies of white bass, yellow perch, and rock bass at Nanticoke (1982-1983) failed to show evidence of predation on smallmouth bass eggs and fry; however, sample sizes of white bass during the spring were small (N < 16) and fish collections were taken in 24-hour gillnet sets at locations removed a considerable distance from the discharge channel where smallmouth bass spawning was doubtful (see Section 4.1).

Angler preference shifted from white bass to smallmouth bass following opening day of bass fishing. Catch success of smallmouth bass anglers in the NTGS outfall was as good or better than in Inner Bay, which is renowned for its bass fishing opportunities. The apparent large abundance of smallmouth bass in the warmwater discharge area, in part, may be due to increased juvenile recruitment enhanced by accelerated growth (Wismer 1982). Overwinter survival of juvenile bass is a function of body size; large juveniles, are better able to withstand winter starvation because the ratio of energy reserves to metabolic rate increases with fish size (Shuter et al. 1980). Wismer (1982) attributed an increase in juvenile survival and increased minimum size of year classes recruiting to the sport fishery in the thermal discharge of the Bruce "A" generating station to accelerated summer growth.

Fishing opportunities for adult smallmouth bass were much improved by the attraction of bass to the NTGS outfall, and vulnerability of adult bass to angling apparently increased as a direct result. There is some concern that continued accelerated harvest of adult bass might eventually reshape the population into a collection of younger and smaller individuals. Wismer (1980) observed such a change in the smallmouth bass population in the vicinity of the Baie Du Dore nuclear power plant, Lake Huron. He postulated that an accelerated removal of adult bass would reduce the reproductive potential of the population and general quality of fishing (fewer trophy-size fish).

Fish were attracted to the NTGS outfall largely because of temperature and flow. These factors and prey abundance have been cited most often as the cause of fish invasions into thermal discharges (Moore et al. 1973, Landry and Strawn 1973, Neill and Magnuson 1974, Storr and Schlenker 1974, Spigarelli el al. 1982). At Nanticoke, angler CUE's were highly correlated ($P < 0.05$) with thermal discharge temperature and with ambient nearshore temperature. The attraction effect of temperature was strongest in spring for white bass and smallmouth bass, which is not surprising considering the importance of temperature in regulating spawning activities. That total catch and CUE's of white bass and smallmouth bass were higher in the discharge channel than in the plume is a good indication that these species preferentially selected areas of the discharge outfall where temperature and flow differentials were maximized. Our results contradict those of Minns et al. (1978) who suggested that fish distributions at Nanticoke were not altered by temperature. However, the results of these authors are not comparable to our own because temperature (temperature rise range: 0-4 versus 0-11°C) and discharge flow levels (range: 26-59 versus 44-138 $m^3/s$) were much different during the respective studies (1974 versus 1982-1983); ie., the NTGS was not fully commissioned in 1974).

Several other studies have detected improved angling success in waters artificially heated by power stations, but unlike the present study those sport fisheries occurred during the colder months, usually November to April (Elser 1965, Gibbons et al. 1972, Landry and Strawn 1973). Marcy and Galvin (1973) found that catch per unit effort of mostly white perch, Morone americana, at a nuclear power plant on the Connecticut River was associated with discharge water temperature. However, Moore and Frisbie (1972) were unable to show such a relationship for white perch and striped bass, Morone saxatilis, at a thermal generating station on the Patuxent River in Maryland.

White bass normally spawn in lake tributaries, but where suitable flowing waters are unavailable, they will also select gravel or rock shoals (Fish 1931). Environmental conditions in the NTGS discharge channel were, except for elevated temperatures, similar to a fast flowing river. Water quality, particularly water clarity, may have been better in the discharge channel (NTGS water intakes were situated some 500 m offshore) than in nearby creeks (Nanticoke Creek, Hickory Creek, Sandusk Creek), which were often loaded with suspended sediments. White bass continue to feed during spawning (Riggs 1955) and prey capture is thought to be more by sight than smell (Green 1962). Low turbidity combined with a probable good abundance of prey species may have helped to lure white bass to the discharge area. That phenomenal catches of white bass (up to 50 bass per rod-hour) on live and artificial baits were experienced by anglers throughout the spring angling season is a good indication that white bass were active feeders during spawning.

The initial arrival of white bass into the NTGS outfall (based on angler catch) at temperatures between 14 and 16°C agrees favourably with the observations of Riggs (1955) who found that mature male white bass separated from bisexual schools and moved inshore when water temperature approached 13 - 16°C. Females apparently remain in the deeper lake waters until their gonads ripen and water temperatures rise to 18°C. The arrival of females at spawning areas can be as much as one month later than that of males (Riggs 1955). In natural lake tributaries the spawning period in a specific locality lasts one to two weeks after which both sexes return to open water (Cahn 1927, Riggs 1955).

At Nanticoke, white bass were abundant for about 7-8 weeks beginning mid-May. Thereafter, a decline in angler CUE's coincided with rising discharge temperatures to above 20°C. On days when anglers were fishing in the spring, water temperature in the discharge outfall averaged 15.3°C (range: 8-20°C) in 1982 and 13.8°C (range: 10-24°C) in 1983. In the same period, lake temperatures averaged 11.6°C (range:

7-14°C) in 1982 and 11.3°C (range: 5-17°C) in 1983. These temperatures were within the reported seasonal thermal preference (16-21°C) of adult white bass (Barans and Tubb 1973). Similarly, discharge temperatures in spring did not exceed the maximum (26°C) preferred by smallmouth bass (Barans and Tubb 1973, Cherry et al. 1975). In the summer, white bass and smallmouth bass exhibited a negative response or no response to discharge temperatures, which averaged 19.4°C (range: 12-25°C) in 1982 and 25.1°C (range: 14-33°C) in 1983. An avoidance response was significant only for white bass in 1982. Summer discharge temperatures in 1982 likely did not exceed the preferred range of white bass (30-32°C) or smallmouth bass (28-31°C) (Ferguson 1958, Barans and Tubb 1973, Reutter and Herdendorf 1976), but during reduced tempering in 1983, outfall temperatures to 33°C were experienced. Correlations of angler CUE's with temperature were weakest in 1983 even though discharge temperatures exceeded the range preferred by white bass and smallmouth bass.

Elevated temperatures may also explain why yellow perch and rock bass were of minor importance in catches of anglers at the NTGS outfall. Seasonal temperature preferences of these species (yellow perch: 10-26°C; rock bass: 20-23°C) are lower than those of white bass (14-32°C) and smallmouth bass (13-31°C) (Hile and Juday 1941, Ferguson 1958, Barans and Tubb 1973, Reutter and Herdendorf 1976). Yellow perch and rock bass were co-dominant (80% or more of the total catch) in the catches of trap nets fished in the peripheral areas of the discharge plume where there was very little angling activity (Section 3.2.1). Bottom temperatures at the plume trap nets were usually less than a degree celsius warmer than ambient lake temperatures. Why yellow perch and rock bass were dominant in trapnet but not sport catches may be because these species tended to concentrate in the cooler peripheral areas of the outfall where the thermal effluent was confined mostly to the surface layer. Discharge water typically mixed to the bottom only within a few hundred metres of the discharge channel (Metcalfe 1982).

The observations of other researchers seem to confirm our own regarding the distribution of yellow perch in thermal effluents. Ross and Winter (1981) found that yellow perch concentrated most often in the peripheral areas of a thermal outfall on the upper Missippi River in Minnesota. In Lake Monona, Wisconsin, yellow perch tended to avoid the thermal discharge outfall of a 220-megawatt power station (Neill and Magnuson 1974). Similarly, yellow perch showed an avoidance to warm water discharges of nuclear power stations on Lake Ontario during the summer, and demonstrated little attraction to warm effluents during winter despite effluent temperatures that were within the species preferred range (Storr and Schlenker 1974).

Meteorological conditions can influence the movement and behaviour of fishes in natural (May et al. 1976, Scholes 1982) and in thermally altered waters (Landry and Strawn 1973, Spigarelli and Thommes 1976). At Nanticoke there was some evidence that weather and wave activity effected the availability of the major sport harvested species. Precipitation and wave activity seemed to improve catch success, but the effect was not consistent over seasons and between years. Furthermore, statistical examinations of the effects of weather and wave activity on CUE's may have been biased by insufficient angling effort on days when weather and wave activity restricted angler participation and performance. Storr and Schlenker (1974) claim that fish were attracted to thermal outfalls partly because an upwelling discharge formed a barrier to wave activity. May et al. (1976) showed that gillnet catches of several marine fishes were higher during weather frontal periods than between frontal periods.

## Summary

Sport fishing activities in the thermal discharge of the Nanticoke Generating Station have increased substantially since hydro production began in 1972. Angling effort in 1982 and 1983 varied spatially and seasonally. Weather and lake conditions explained a significant amount of the day-to-day variations in fishing activity. Daily fluctuations in angler success were temperature dependent and statistically significant correlations of angler CUE's with discharge temperature indicate that fish were distributed in response to species specific temperature preferenda. In spring and fall, white bass and smallmouth bass were attracted to the thermal discharge. During the warmest months (summer) these species avoided the NTGS outfall or were indifferent to temperature fluctuations. Station discharge flow, weather, and wave activity had a minor effect on angler CUE's, but strongly influenced (except for discharge flow) angling activity. Maximum angling pressure and largest fish catches occurred in May and June when white bass invaded the discharge area to spawn. After spawning, catch success of white bass declined steadily, but anglers still averaged from one to two white bass/rod-hour in fall when fishing for this species was the worst. Fishing opportunities for smallmouth bass were also excellent relative to other areas in Long Point Bay.

Excellent fishing opportunities for white bass and smallmouth bass within a small area of the NTGS outfall (> 0% of boat parties fished in a 2.5 ha area of the outfall) resulted in angler crowding and exceptional harvest densities (No./ha). Fishing pressure is expected to increase as popularity of the fishery expands, especially in the spring when anglers may seek an alternate fishing experience to opportunities previously enjoyed in Inner Bay before the recent imposition of a bass spawning sanctuary. Increased vulnerability of fish concentrated in the thermal discharge, coupled with increased angling pressure, warrants some concern of possible over-harvest of the principal species and decreased recruitment of smallmouth bass through disturbance of their nesting activities before open season. The increased vulnerability of adult fish to angling may have some potentially negative effects on local populations (reduced spawning potential) and the sport fishery (fewer trophy fish). However, such effects on smallmouth bass at least, may be offset somewhat by increased recruitment, which may arise from increased over-winter survival, enhanced by faster summer growth in the thermal plume.

Table 3.2.4-1. Survey frequency and period of creel census by season on the NTGS outfall, 1982-1983.

| Season | Year | N[1] | $n_1$[2] | $n_2$[3] | Survey Period |
|---|---|---|---|---|---|
| Spring | 1982 | 86 | 44 | 14 | April 1 to June 25 |
| | 1983 | 85 | 31 | 6 | April 1 to June 24 |
| Summer | 1982 | 89 | 54 | 14 | June 26 to Sept. 22 |
| | 1983 | 90 | 44 | 10 | June 25 to Sept. 22 |
| Fall | 1982 | 69 | 40 | 3 | Sept. 23 to Nov. 30 |
| | 1983 | 39 | 21 | 1 | Sept. 23 to Oct. 31 |
| Survey Period | 1982 | 244 | 138 | 31 | April 1 to Nov. 30 |
| | 1983 | 214 | 96 | 17 | April 1 to Oct. 30 |

[1] N = Total number of days in sampling period.

[2] $n_1$ = Number of scheduled creel census days.

[3] $n_2$ = Number of unscheduled creel census days; these data were used in estimates of catch, harvest, and CUE's for some 1982 strata and in correlations and regression analyses; all other analyses used only data from scheduled creel census.

Table 3.2.4-2. Distribution of estimated angling effort (rod-hours) and mean daily effort (MDE) by area, season, and year on the NTGS outfall, 1982-1983.

| | | | Area | | | | | |
|---|---|---|---|---|---|---|---|---|
| Season | Year | No. Days | Discharge Channel | (MDE)[1] | Plume | (MDE) | Outfall | (MDE) |
| Spring | 1982 | 86 | 4381 | (50.9) | 1929 | (22.4) | 6310 | (73.4) |
| | 1983 | 85 | 4570 | (53.8) | 1965 | (23.1) | 6535 | (76.9) |
| Summer | 1982 | 89 | 3271 | (36.8) | 4549 | (51.1) | 7820 | (87.9) |
| | 1983 | 90 | 3659 | (40.7) | 3705 | (41.2) | 7364 | (81.8) |
| Fall | 1982 | 69 | 863 | (12.5) | 468 | (6.8) | 1331 | (19.3) |
| | 1983 | 39 | 595 | (15.3) | 855 | (21.9) | 1450 | (37.2) |
| Survey Period | 1982 | 244 | 8515 | (34.9) | 6946 | (28.5) | 15461 | (63.4) |
| | 1983 | 214 | 8824 | (41.2) | 6526 | (30.5) | 15349 | (71.1) |

[1] Estimates of MDE were based on theoretical day-length (sunrise to sunset) which averaged 14 hours in spring and summer and 11 hours in fall.

Table 3.2.4-3. Distribution of estimated angling effort (rod-hours) and mean daily effort (MDE) by season, day-type and year on the NTGS outfall, 1982-1983.

| | | Weekday | | | Weekend | | |
|---|---|---|---|---|---|---|---|
| Season | Year | No. Days | Effort | (MDE)[1] | No. Days | Effort | (MDE) |
| Spring | 1982 | 59 | 4162 | (70.5) | 27 | 2148 | (79.5) |
| | 1983 | 58 | 3465 | (59.7) | 27 | 3070 | (113.7) |
| Summer | 1982 | 60 | 3344 | (55.7) | 29 | 4476 | (154.3) |
| | 1983 | 61 | 2912 | (47.7) | 29 | 4452 | (153.5) |
| Fall | 1982 | 47 | 948 | (20.1) | 22 | 383 | (17.4) |
| | 1983 | 26 | 581 | (22.3) | 13 | 869 | (66.8) |
| Survey Period | 1982 | 166 | 8545 | (51.4) | 78 | 7007 | (89.8) |
| | 1983 | 145 | 6958 | (48.0) | 69 | 8391 | (121.6) |

[1] Estimates of MDE were based on theoretical day-length (sunrise to sunset) which averaged 14 hours in spring and summer and 11 hours in fall.

Table 3.2.4-4. Catch and harvest estimates of the sport fishery on the NTGS outfall, 1982-1983.

| | 1982 | | 1983 | |
|---|---|---|---|---|
| Species | Catch | Harvest | Catch | Harvest |
| White bass | 51493 | 47535 | 54858 | 44374 |
| Smallmouth bass | 8863 | 3530 | 5442 | 1862 |
| Yellow perch | 3905 | 3403 | 2692 | 2364 |
| Rock bass | 3626 | 1233 | 2183 | 1062 |
| Freshwater drum | 3665 | 283 | 2861 | 533 |
| White perch | 144* | 0 | 370 | 344 |
| Pumpkinseed | 7* | 0 | 213 | 0 |
| Bluegill | 0 | 0 | 30* | 30 |
| Black crappie | 0 | 0 | 81* | 40 |
| White crappie | 0 | 0 | 85 | 85 |
| Largemouth bass | 0 | 0 | 62* | 0 |
| Walleye | 0 | 0 | 8* | 0 |
| Carp | 0 | 0 | 22* | 0 |
| Yellow bullhead | 0 | 0 | 5* | 5 |
| Channel catfish | 144* | 144 | 0 | 0 |
| Rainbow trout | 0 | 0 | 8* | 8 |
| Total | 71847 | 56128 | 68920 | 50697 |

* Estimates derived from observed catch (harvest) of three or fewer fish.

Table 3.2.4-5. Percentage of anglers seeking particular species on the NTGS outfall, 1982-1983.[1]

| | | | Species | | | |
|---|---|---|---|---|---|---|
| Season | Year | No. Interviews | White Bass | Smallmouth Bass | Yellow Perch | Walleye |
| Spring | 1982 | 40 | 90 | 0 | 38 | 0 |
| | 1983 | 123 | 77 | 0 | 19 | 2 |
| Summer | 1982 | 60 | 73 | 55 | 27 | 2 |
| | 1983 | 179 | 46 | 36 | 15 | 1 |
| Fall | 1982 | 32 | 53 | 66 | 19 | 16 |
| | 1983 | 51 | 33 | 43 | 6 | 14 |
| Survey Period | 1982 | 132 | 73 | 41 (59)[2] | 28 | 5 |
| | 1983 | 353 | 55 | 24 (37)[2] | 15 | 3 |

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[1] Angling preference was expressed as a percentage of species fishermen over all fishermen. Some fishermen sought more than one species, whereas others did not indicate any preference.

[2] Values in brackets are percentages during open season (summer and fall) of smallmouth bass.

Table 3.2.4-6. Catch (C) and harvest (H) of white bass and smallmouth bass by area, season, and year on the NTGS outfall, 1982-1983.

| | | AREA | | | | | |
|---|---|---|---|---|---|---|---|
| | | Discharge Channel | | Plume | | Outfall | |
| Season | Year | C | H | C | H | C | H |
| | | **White bass** | | | | | |
| Spring | 1982 | 32179 | 30115 | 2847 | 2741 | 35026 | 32856 |
| | 1983 | 22258 | 19752 | 8125 | 8005 | 30383 | 27757 |
| Summer | 1982 | 10817 | 9238 | 4497 | 4425 | 15314 | 13663 |
| | 1983 | 13665 | 10358 | 9038 | 5166 | 22703 | 15524 |
| Fall | 1982 | 1145 | 1008 | 8 | 8 | 1153 | 1016 |
| | 1983 | 819 | 609 | 948 | 484 | 1768 | 1093 |
| Survey Period | 1982 | 44141 | 40361 | 7352 | 7174 | 51493 | 47535 |
| | 1983 | 36743 | 30719 | 18111 | 13655 | 54854 | 44374 |
| | | **Smallmouth bass** | | | | | |
| Spring | 1982 | 2916 | 217 | 395 | 0 | 3311 | 217 |
| | 1983 | 1593 | 0 | 212 | 0 | 1804 | 0 |
| Summer | 1982 | 2626 | 1101 | 2523 | 1834 | 5149 | 2935 |
| | 1983 | 1286 | 477 | 1737 | 939 | 3023 | 1416 |
| Fall | 1982 | 253 | 248 | 150 | 130 | 403 | 378 |
| | 1983 | 76 | 76 | 539 | 369 | 615 | 446 |
| Survey Period | 1982 | 5795 | 1566 | 3068 | 1964 | 8863 | 3530 |
| | 1983 | 2955 | 544 | 2487 | 1308 | 5442 | 1862 |

Table 3.2.4-7. Catch per unit effort of the principle species in the sport fishery on the NTGS outfall by area and by season, 1982-1983.

| Species | Year | CUE[1] Type | Area | | Season[3] | | |
|---|---|---|---|---|---|---|---|
| | | | Discharge Channel | Plume | Spring | Summer | Fall |
| White bass | 1982 | All anglers | 4.386 | ND[2] | 7.259 | 3.010 | 1.047 |
| | | Species anglers | 4.820 | ND | 7.528 | 3.252 | 1.189 |
| | 1983 | All anglers | 3.765 | 2.352 | 4.727 (4.387) | 3.094 (2.650) | 1.573 (1.204) |
| | | Species anglers | 3.852 | 3.005 | 4.846 (4.618) | 2.871 (2.760) | 2.069 (1.856) |
| Smallmouth bass | 1982 | All anglers | 0.546 | ND | 0.479 | 0.697 | 0.284 |
| | | Species anglers | 0.784 | ND | | 0.979 | 0.336 |
| | 1983 | All anglers | 0.337 | 0.421 | 0.356 (0.284) | 0.372 (0.424) | 0.120 (0.479) |
| | | Species anglers | 0.439 | 0.691 | | 0.534 (0.560) | 0.171 (0.656) |
| Yellow perch | 1982 | All anglers | 0.284 | ND | 0.306 | 0.364 | 0.000 |
| | | Species anglers | 0.642 | ND | 0.612 | 0.722 | 0.000* |
| | 1983 | All anglers | 0.093 | 0.149 | 0.063 (0.134) | 0.125 (0.129) | 0.120 (0.054) |
| | | Species anglers | 0.238 | 0.963 | 0.172 (0.454) | 0.279 (0.446) | 0.583* (0.583)* |
| Rock bass | 1982 | All anglers | 0.296 | ND | 0.336 | 0.270 | 0.271 |
| | | Species anglers | 0.932 | ND | | 0.222* | 1.714* |
| | 1983 | All anglers | 0.129 | 0.158 | 0.113 (0.091) | 0.172 (0.192) | 0.051 (0.144) |
| | | Species anglers | | 0.698 | | (0.139) | |

[1] All anglers CUE = observed catch of all anglers/observed effort of all anglers;
Species anglers CUE = observed catch of species anglers/observed effort species anglers.

[2] ND = No data.

[3] CUE's are for the discharge channel only; CUE's in brackets are for the outfall (discharge channel and plume).

* CUE based on interviews of three or fewer boat parties.

Table 3.2.4-8. Mean TL (mm) by year class of the principal species (sexes combined) harvested in the sport fishery on the NTGS outfall, 1982-1983.

| | | | Year Class | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Year | Statistic | 1982 | 1981 | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 |
| White bass | 1982 | Mean | | 197 | 254 | 279 | | | | | | |
| | | SD | | 9.9 | 22.0 | 41.6 | | | | | | |
| | | N | | 2 | 84 | 3 | | | | | | |
| | 1983 | Mean | 213 | 247 | 301 | | 354 | 376 | | | | |
| | | SD | 19.8 | 18.9 | 16.7 | | 37.5 | 17.7 | | | | |
| | | N | 9 | 212 | 170 | | 2 | 5 | | | | |
| Smallmouth bass | 1982 | Mean | | | 246 | 304 | 325 | 375 | 369 | | | 482 |
| | | SD | | | 22.1 | 9.9 | 28.4 | 17.8 | 14.8 | | | --- |
| | | N | | | 5 | 3 | 10 | 4 | 4 | | | 1 |
| | 1983 | Mean | 186 | 250 | 302 | 341 | 385 | 404 | | 470 | 482 | |
| | | SD | 8.1 | 30.5 | 28.0 | 22.5 | 27.7 | 19.0 | | --- | --- | |
| | | N | 6 | 13 | 25 | 6 | 14 | 7 | | 1 | 1 | |
| Yellow perch | 1982 | Mean | | | 190 | 210 | | | | | | |
| | | SD | | | 20.7 | 33.8 | | | | | | |
| | | N | | | 4 | 10 | | | | | | |
| | 1983 | Mean | | 184 | 197 | 219 | 230 | | | | | |
| | | SD | | 24.3 | 7.4 | --- | --- | | | | | |
| | | N | | 21 | 5 | 1 | 1 | | | | | |

Table 3.2.4-9. Correlations of environmental variables with angler CUE's ($\log_{10} x + 0.01$) of white bass and smallmouth bass on the NTGS outfall, 1982-1983.

| | | | ENVIRONMENTAL VARIABLES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | SEASON | STATISTIC | PRECIP | AIR TEMP | WIND DIRECTION | WIND SPEED | INTAKE TEMP | OUTFALL TEMP | TEMP RISE | DISCHARGE FLOW | POWER PRODUCTION | WAVE INDEX | WAVE HEIGHT |
| | | | | | | WHITE BASS | | | | | | | |
| 1982 | Spring | r | 0.020 | 0.296 | 0.031 | -0.256 | 0.850** | 0.785** | 0.348 | 0.447* | 0.264 | -0.056 | -0.160 |
| | | N | 25 | 25 | 25 | 25 | 24 | 24 | 24 | 23 | 25 | 25 | 22 |
| | Summer | r | -0.182 | 0.277 | 0.027 | 0.018 | -0.485* | -0.391* | -0.051 | 0.223 | -0.042 | 0.117 | 0.129 |
| | | N | 35 | 31 | 30 | 31 | 35 | 34 | 34 | 33 | 35 | 30 | 30 |
| | Fall | r | 0.095 | -0.010 | 0.122 | 0.353 | 0.320 | 0.648* | 0.234 | 0.063 | 0.278 | 0.232 | 0.832* |
| | | N | 16 | 14 | 15 | 14 | 15 | 14 | 13 | 15 | 16 | 14 | 11 |
| 1983 | Spring | r | 0.072 | 0.392* | 0.216 | 0.079 | 0.579** | 0.424* | 0.157 | 0.030 | -0.100 | 0.230 | -0.163 |
| | | N | 29 | 26 | 26 | 26 | 29 | 29 | 29 | 29 | 29 | 26 | 29 |
| | Summer | r | 0.375* | -0.244 | 0.220 | 0.335 | -0.025 | -0.086 | -0.134 | 0.281 | -0.039 | 0.341 | 0.357* |
| | | N | 33 | 28 | 27 | 28 | 33 | 33 | 33 | 33 | 33 | 27 | 32 |
| | Fall | r | 0.000 | -0.181 | -0.644 | 0.309 | -0.308 | 0.094 | 0.394 | 0.590 | 0.510 | -0.305 | 0.460 |
| | | N | 7 | 5 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | 6 | 7 |
| | | | | | | SMALLMOUTH BASS | | | | | | | |
| 1982 | Spring | r | 0.082 | 0.162 | -0.303 | 0.053 | 0.219 | 0.564* | 0.550* | 0.230 | 0.258 | -0.186 | 0.077 |
| | | N | 25 | 25 | 25 | 25 | 24 | 24 | 24 | 23 | 25 | 25 | 22 |
| | Summer | r | -0.097 | 0.176 | -0.155 | -0.293 | -0.296 | -0.218 | -0.039 | 0.063 | -0.002 | -0.121 | -0.342 |
| | | N | 35 | 31 | 30 | 31 | 35 | 34 | 34 | 33 | 35 | 30 | 30 |
| | Fall | r | 0.572* | 0.554* | 0.275 | 0.301 | 0.602* | 0.555* | -0.037 | 0.340 | -0.145 | 0.274 | 0.507 |
| | | N | 16 | 14 | 15 | 14 | 15 | 14 | 13 | 15 | 16 | 14 | 11 |
| 1983 | Spring | r | 0.227 | 0.151 | 0.096 | -0.246 | 0.427* | 0.485* | 0.426* | 0.361 | 0.304 | -0.178 | 0.097 |
| | | N | 29 | 26 | 26 | 26 | 29 | 29 | 29 | 29 | 29 | 26 | 29 |
| | Summer | r | 0.444* | -0.183 | 0.020 | 0.274 | 0.071 | 0.122 | 0.155 | 0.300 | 0.066 | 0.145 | 0.168 |
| | | N | 33 | 28 | 27 | 28 | 33 | 33 | 33 | 33 | 33 | 27 | 32 |
| | Fall | r | 0.000 | 0.338 | -0.421 | 0.092 | -0.209 | 0.286 | 0.585 | 0.517 | 0.672 | -0.262 | 0.042 |
| | | N | 7 | 5 | 6 | 6 | 7 | 7 | 7 | 7 | 7 | 6 | 7 |

* Correlation significant at $P \leq 0.05$

** Correlation significant at $P \leq 0.001$

Table 3.2.4-10. Summary statistics of sport fish CUE's and environmental variables observed during the spring, summer and fall angling season on the NTGS outfall, 1982-1983.

A.

| Variable | MEAN ± SD (N) DURING SPECIFIED ANGLING PERIOD IN 1982 and 1983 | | | | | |
|---|---|---|---|---|---|---|
| | 1982 | | | 1983 | | |
| | Spring | Summer | Fall | Spring | Summer | Fall |
| No. Boat Parties per census | 3.4 ± 2.3<br>(25) | 2.5 ± 1.8<br>(35) | 1.2 ± 0.5<br>(16) | 3.0 ± 1.8<br>(29) | 1.7 ± 1.1<br>(33) | 1.6 ± 0.8<br>(7) |
| White Bass per rod-hour | 7.726 ± 6.036<br>(25) | 3.593 ± 5.534<br>(35) | 0.712 ± 1.844<br>(16) | 4.822 ± 3.841<br>(29) | 5.387 ± 10.704<br>(33) | 1.389 ± 0.782<br>(7) |
| Smallmouth bass per rod-hour | 0.704 ± 0.842<br>(25) | 1.045 ± 2.755<br>(35) | 0.342 ± 0.745<br>(16) | 0.280 ± 0.582<br>(29) | 0.378 ± 0.659<br>(33) | 0.051 ± 0.105<br>(7) |
| Air Temperature (°C) | 16.9 ± 3.9<br>(25) | 19.1 ± 4.1<br>(31) | 9.8 ± 5.7<br>(14) | 16.1 ± 5.9<br>(26) | 21.6 ± 4.7<br>(28) | 14.8 ± 4.9<br>(5) |
| Wind Speed (km/h) | 10.8 ± 4.2<br>(25) | 8.7 ± 4.9<br>(31) | 8.0 ± 3.0<br>(14) | 9.1 ± 4.7<br>(26) | 8.3 ± 3.6<br>(28) | 10.1 ± 3.8<br>(6) |
| Intake Temperature (°C) | 11.6 ± 1.8<br>(24) | 16.6 ± 2.7<br>(35) | 14.9 ± 2.9<br>(15) | 11.3 ± 2.7<br>(29) | 19.4 ± 3.6<br>(33) | 14.9 ± 3.9<br>(7) |
| Outfall Temperature (°C) | 15.3 ± 2.7<br>(24) | 19.4 ± 3.6<br>(34) | 16.4 ± 3.9<br>(14) | 13.8 ± 3.9<br>(29) | 25.1 ± 5.5<br>(33) | 20.1 ± 4.8<br>(7) |
| Temperature Rise (°C) | 3.9 ± 1.7<br>(24) | 2.6 ± 1.5<br>(34) | 2.0 ± 1.9<br>(13) | 2.7 ± 2.1<br>(29) | 5.9 ± 2.7<br>(33) | 5.4 ± 3.2<br>(7) |
| Discharge Flow ($m^3/s$) | 117 ± 15<br>(23) | 109 ± 15<br>(33) | 102 ± 16<br>(15) | 95 ± 14<br>(29) | 79 ± 14<br>(33) | 67 ± 13<br>(7) |
| Power Production (MW) | 1807 ± 552<br>(25) | 1400 ± 645<br>(35) | 1174 ± 648<br>(16) | 964 ± 801<br>(29) | 1922 ± 811<br>(33) | 1416 ± 737<br>(7) |
| Wave Index | 976 ± 675<br>(25) | 728 ± 678<br>(30) | 631 ± 546<br>(14) | 945 ± 627<br>(26) | 782 ± 648<br>(27) | 938 ± 437<br>(6) |

B.

| Variable | Interval | PERCENT FREQUENCY DURING SPECIFIED ANGLING PERIOD IN 1982 and 1983 | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1982 | | | 1983 | | |
| | | Spring | Summer | Fall | Spring | Summer | Fall |
| Wave Height (m) | <1/3 | 73 | 90 | 64 | 52 | 47 | 43 |
| | 1/3 to <2/3 | 27 | 3 | 9 | 41 | 28 | 0 |
| | 2/3 to <1 | 0 | 7 | 18 | 7 | 19 | 57 |
| | 1 to <1-1/3 | 0 | 0 | 9 | 0 | 3 | 0 |
| | >1-1/3 | 0 | 0 | 0 | 0 | 3 | 0 |
| | (No. obs) | (22) | (30) | (11) | (29) | (32) | (7) |
| Precipitation (mm) | 0 | 44 | 60 | 69 | 93 | 91 | 100 |
| | >0 to 5 | 36 | 31 | 31 | 7 | 9 | 0 |
| | >5 to 10 | 8 | 6 | 0 | 0 | 0 | 0 |
| | >10 to 15 | 8 | 0 | 0 | 0 | 0 | 0 |
| | >15 to 20 | 0 | 0 | 0 | 0 | 0 | 0 |
| | >20 to 25 | 0 | 3 | 0 | 0 | 0 | 0 |
| | >25 to 30 | 0 | 0 | 0 | 0 | 0 | 0 |
| | >30 to 35 | 4 | 0 | 0 | 0 | 0 | 0 |
| | (No. obs) | (25) | (35) | (16) | (29) | (33) | (7) |
| Wind Direction | N | 8 | 13 | 7 | 8 | 11 | 0 |
| | NE | 28 | 7 | 13 | 15 | 22 | 0 |
| | E | 4 | 10 | 20 | 8 | 0 | 17 |
| | SE | 4 | 7 | 7 | 15 | 7 | 17 |
| | S | 16 | 3 | 0 | 23 | 7 | 0 |
| | SW | 24 | 13 | 13 | 15 | 30 | 17 |
| | W | 12 | 30 | 13 | 12 | 11 | 33 |
| | NW | 4 | 17 | 27 | 4 | 11 | 17 |
| | (No. obs) | (25) | (30) | (15) | (26) | (24) | (6) |
| | Onshore | 52 | 37 | 27 | 65 | 48 | 67 |
| | Offshore | 48 | 63 | 73 | 35 | 52 | 33 |
| | (No. obs) | (25) | (30) | (15) | (26) | (27) | (7) |

[a] Data are means and associated standard deviations (SD) of unweighted CUE's observed during creel census periods, the means themselves are not true unweighted estimates of CUE.

Table 3.2.4-11. Regression equations for predicting angler catch success (CUE) of white bass and smallmouth bass on the NTGS outfall, 1982-1983.

| | | | | | | | Fraction of $R^2$ explained by* each independent variable | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Season | Eq. No. | Equation[1] | N | $R^2$ | P | OTEMP | FLOW | WAVE | PRECIP |
| | | | **White bass** | | | | | | | |
| 1982 | Spring | 1 | log CUE = -4.8556 + 0.3191 OTEMP + 0.0004 WAVE | 22 | 0.698 | 0.0001 | 0.637 | --- | 0.062 | --- |
| | Summer | 2 | log CUE = -0.0381 - 0.0892 OTEMP + 0.0175 FLOW - 0.2741 PRECIP | 28 | 0.282 | 0.0441 | 0.118 | 0.083 | --- | 0.081 |
| 1983 | Spring | 3 | log CUE = -1.4778 + 0.1059 OTEMP + 0.0004 WAVE | 26 | 0.241 | 0.0421 | 0.172 | --- | 0.068 | --- |
| | Summer | 4 | log CUE = -1.0796 - 0.0428 OTEMP + 0.0209 FLOW + 0.0004 WAVE + 0.8819 PRECIP | 27 | 0.243 | 0.1715 | 0.125 | 0.021 | 0.063 | 0.034 |
| | | | **Smallmouth bass** | | | | | | | |
| 1982 | Spring | 5 | log CUE = -2.446 + 0.1805 OTEMP - 0.0075 FLOW | 22 | 0.330 | 0.0221 | 0.317 | 0.013 | --- | --- |
| | Summer | 6 | log CUE = -0.1563 - 0.0395 OTEMP + 0.0085 FLOW - 0.0010 WAVE - 0.1060 PRECIP | 28 | 0.471 | 0.0042 | 0.024 | 0.017 | 0.413 | 0.017 |
| 1983 | Spring | 7 | log CUE = -3.2103 + 0.0744 OTEMP + 0.0114 FLOW - 0.0002 WAVE + 0.9161 PRECIP | 26 | 0.348 | 0.0522 | 0.248 | 0.020 | 0.033 | 0.047 |
| | Summer | 8 | log CUE = -3.0017 + 0.0227 FLOW + 0.9878 PRECIP | 27 | 0.280 | 0.0195 | --- | 0.206 | --- | 0.074 |

[1] Logarithms are to the base 10.

* OTEMP = outfall temperature FLOW = discharge flow WAVE = wave index PRECIP = precipitation.

Table 3.2.4-12. Comparative effort and harvest data of sport fisheries in the Canadian portion of Lake Erie and connecting waters, 1980-1983.

| Survey Years | Survey Duration (No. Days) | Total Effort (rod-hours) | Effort Density (rod-hours/ha) | Total Harvest | Principal Species[1] Harvested | % of Total Harvest | Data Source |
|---|---|---|---|---|---|---|---|
| **UPPER NIAGARA RIVER[2] (1012 ha)** | | | | | | | |
| 1980 | 72 | 31120 | 30.8 | 17659 | YP | 45 | Lewis and Dimond 1982 |
| **GRAVELLY BAY, PORT COLBORNE[3] (200 ha)** | | | | | | | |
| 1980 | 72 | 13003 | 65.0 | 6184 | YP<br>SMB<br>RB | 49<br>22<br>21 | Lewis and Dimond 1982 |
| **PORT MAITLAND PIER** | | | | | | | |
| 1980 | 72 | 16613 | | 9938 | WB<br>FWD<br>YP | 35<br>29<br>21 | Lewis and Dimond 1982 |
| **NANTICOKE THERMAL GENERATING STATION (121 ha, 0.9 ha[4])** | | | | | | | |
| 1982 | 244 | 15461<br>(8515)[4] | 127.8<br>(9461)[4] | 56128 | WB<br>SMB<br>YP | 85<br>6<br>6 | Witzel 1984a |
| 1983 | 214 | 15349<br>(8824)[4] | 126.9<br>(9804)[4] | 50697 | WB<br>YP<br>SMB | 88<br>5<br>4 | Witzel 1985a |
| **LONG POINT BAY (17797 ha)** | | | | | | | |
| 1982 | 92 | 273342 | 15.6 | 208219 | YP<br>SMB<br>RB | 36<br>35<br>22 | Reid 1984a |
| 1983 | 123 | 206360 | 16.1 | 202303 | YP<br>SMB<br>RB | 36<br>33<br>21 | Reid 1984b |
| **RONDEAU BAY (2700 ha)** | | | | | | | |
| 1982 | 92 | 32852 | 12.2 | 28559 | YP<br>WB | 51<br>12 | Hyatt 1983a |
| 1983 | 60 | 32892 | 12.2 | 28267 | YP<br>BC | 37<br>22 | Battson 1985 |
| **WESTERN BASIN (72552 ha)** | | | | | | | |
| 1982 | 62 | 106566 | 1.5 | 60268 | WE<br>SMB | 80<br>9 | Hyatt 1983b |
| 1983 | 62 | 116649 | 1.6 | 59748 | WE<br>SMB | 67<br>24 | Hyatt 1984b |
| **DETROIT RIVER (2728 ha)** | | | | | | | |
| 1980 | 105 | 143295 | 52.5 | 161644 | WB<br>WE | 64<br>19 | Witzel 1984c |

---

[1] BC = black crappie, FWD = freshwater drum, RB = rock bass, SMB = smallmouth bass, WB = white bass, WE = walleye, WP = white perch, YP = yellow perch.

[2] Survey included anglers fishing in the New York portion of the Upper Niagra River (approximately 47% of total angling effort).

[3] Survey included shore and boat anglers.

[4] Values in brackets are for the discharge channel (0.9 ha) only.

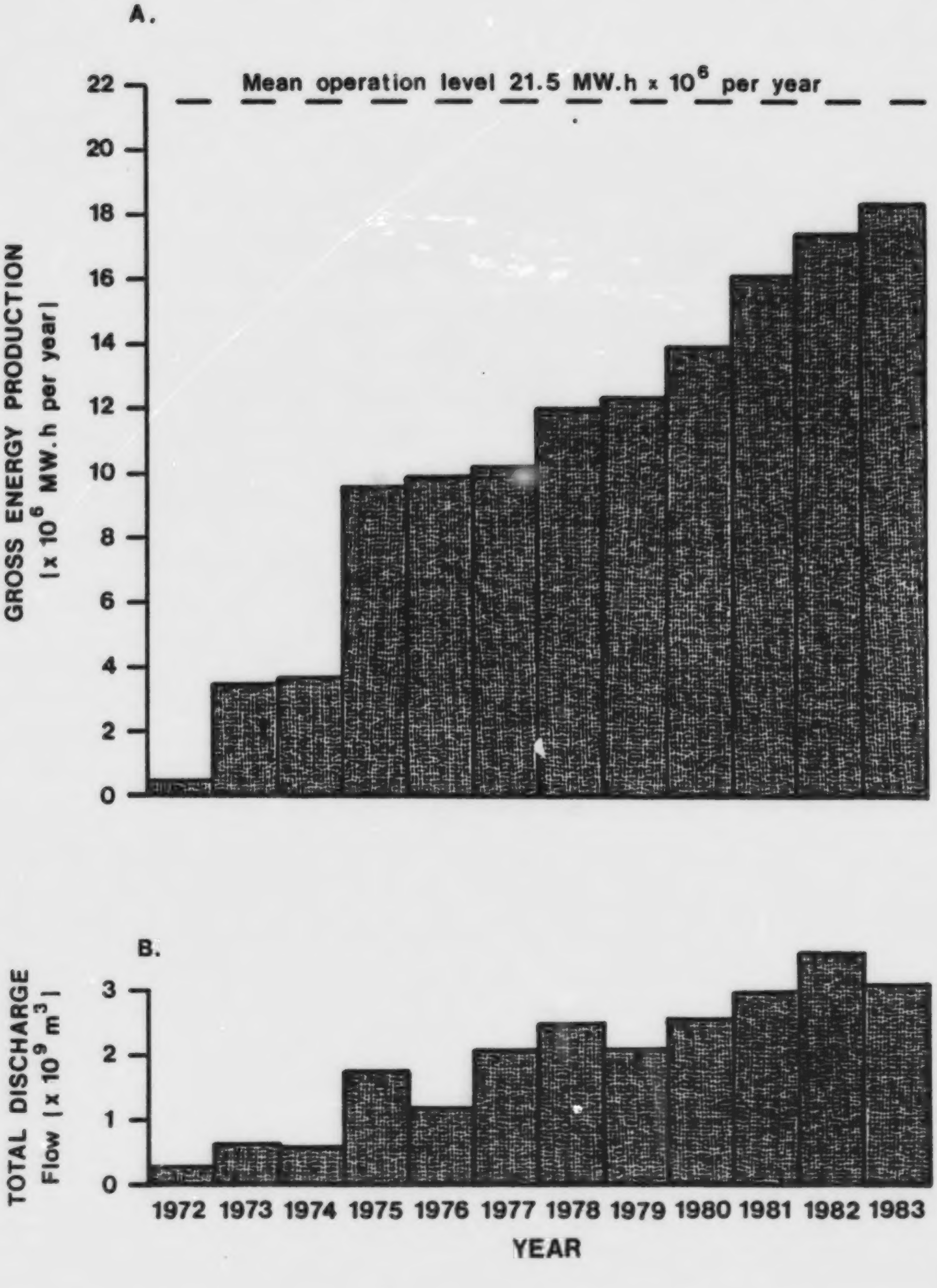


Figure 3.2.4-1. Gross energy production and total station water flow volumes at the Nanticoke Thermal Generating Station, 1972-1983.

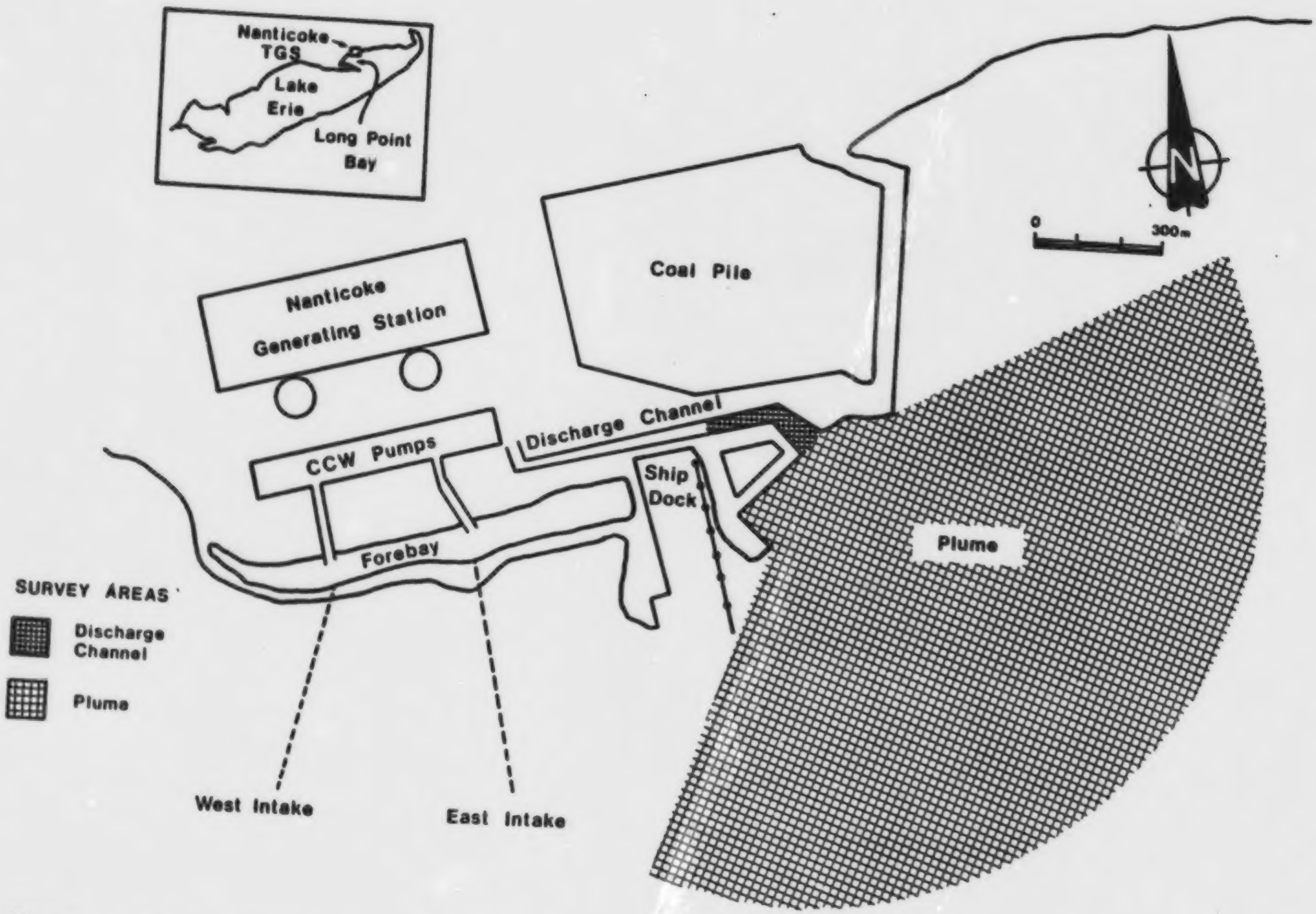

Nanticoke TGS
Lake Erie
Long Point Bay
0
300m
N
Coal Pile
Nanticoke Generating Station
CCW Pumps
Discharge Channel
Ship Dock
Forebay
Plume
SURVEY AREAS
Discharge Channel
Plume
West Intake
East Intake

Figure 3.2.4-2. Areas surveyed in the discharge channel and plume of the Nanticoke Thermal Generating Station, 1982-1983.

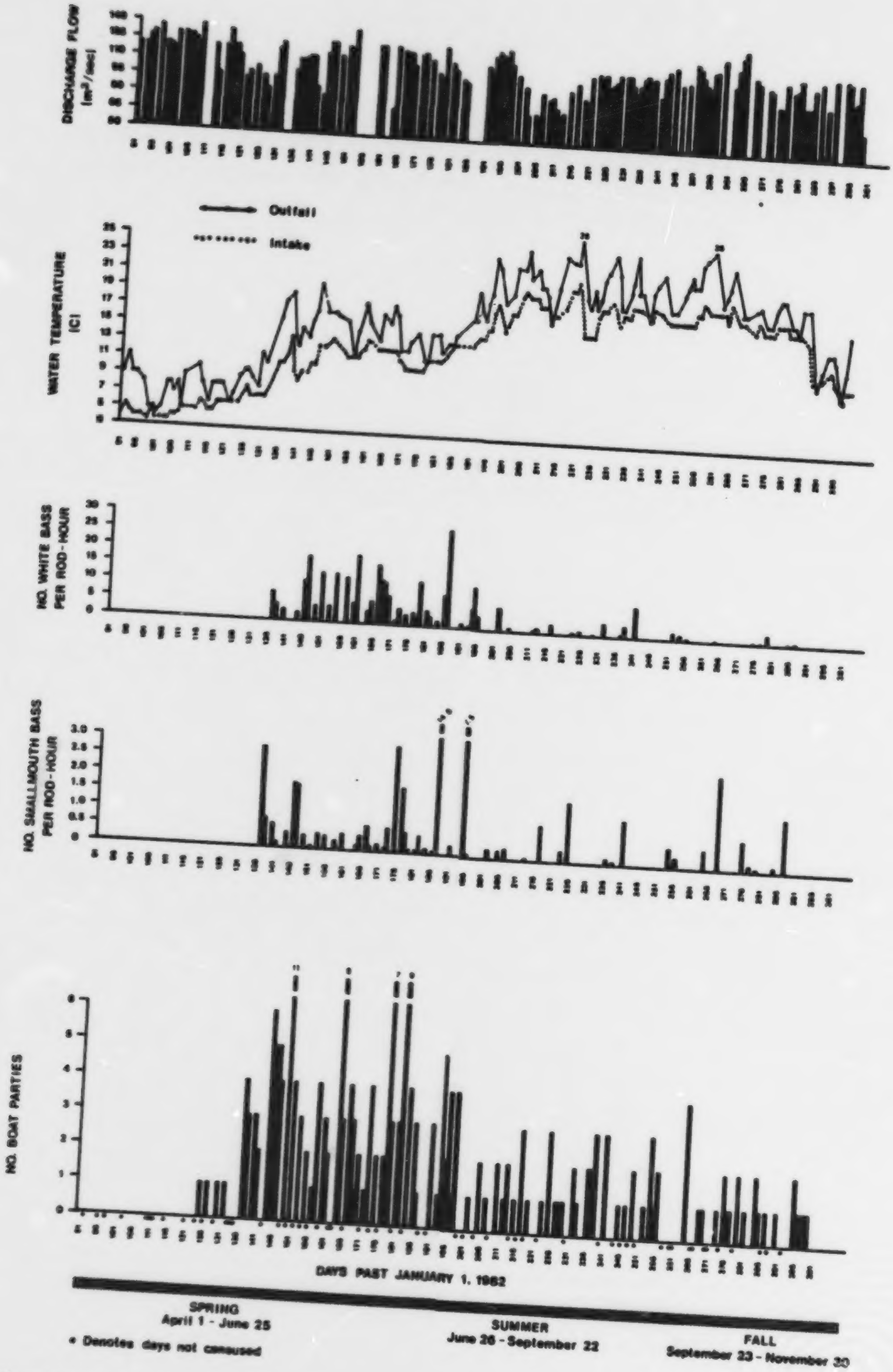


Figure 3.2.4-3. Daily measures of discharge flow, water temperatures, angler success rates (CUE's), and fishing pressure (No. boat parties) observed during the spring, summer, and fall angling seasons on the NTGS outfall, 1982.

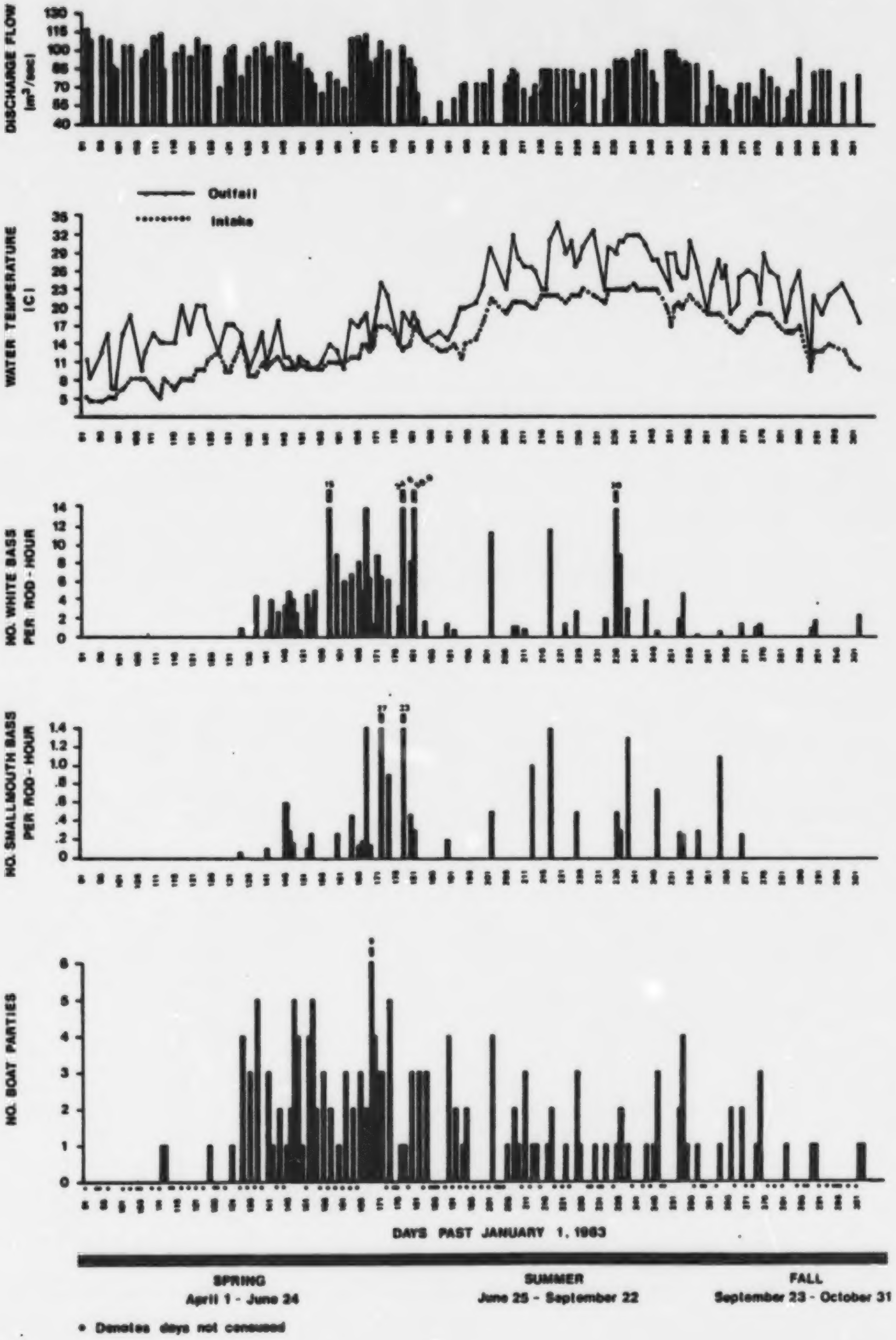


Figure 3.2.4-4. Daily measures of discharge flow, water temperatures, angler success rates (CUE's), and fishing pressure (No. boat parties) observed during the spring, summer, and fall angling seasons on the NTGS outfall, 1983.

### 3.2.5 Fish Migrations and Movements

#### Introduction

Fish are free-ranging animals, their activities may at some time in their life extend far beyond a "home" range to which they eventually return (Gerking 1953). Documented examples pertain mostly to migrations of fish to spawning areas (eg. Crowe 1962, Ferguson and Derksen 1971, Clady 1977, Pflug and Pauley 1983). In Long Point Bay, knowledge of fish migrations is of considerable value in assessing the effects of industrial activities at Nanticoke on the local fish populations, which migrate to or from the areas (for example: NTGS plume) impacted on by industry.

Mark and recapture studies were initiated in 1971 to obtain valuable information on long-distance travels of predominately rock bass, yellow perch, and smallmouth bass in Long Point Bay. Tagged fish returns during the preoperational phase (1971-1979) of industrial development indicated that populations in the Nanticoke area ranged throughout and to some extent beyond Long Point Bay (Kelso 1973b, Scrutton and MacLean 1981). MacLean and Teleki (1977) demonstrated that rock bass in the Nanticoke area remained within a home range during the non-reproductive period, but during the spawning season in spring, migrated some 35 to 40 km to Inner Bay. Evidence of a similar spawning migration by yellow perch was not conclusive (Scrutton and MacLean 1981), but indicated a need for further study. This report describes the recent (1981-1983) observations on the movements of yellow perch, rock bass, and smallmouth bass during the operational period when industry at Nanticoke was approaching or operating at optimal capacity.

Moment-to-moment activities of fish could not be differentiated by simply noting where marked fish were released and subsequently recaptured. We examined the finer details of fish movements by means of ultrasonic telemetry, i.e., by tracking high frequency vibrations emitted by small transmitters attached to individual fish. The purpose of our telemetry studies (1975-1977) was to determine if heated water discharged from the Nanticoke T.G.S. altered the migrations of rock bass, yellow perch, and smallmouth bass; to assess whether or not fish resided in, were attracted to or repelled from the warm water plume, and if their movements were in response to specific environmental variables. The results of the ultrasonic telemetry studies described in this report were taken from MacLean et al. (1981, 1982).

## Methods

### A. Mark-Recapture

The following methods pertain only to the years 1981 to 1983. Descriptions of earlier mark-recapture (tagging) methods can be found in references cited in the above introduction and in several unpublished annual reports (Kelso 1972, 1973a, Teleki 1973, 1976, Teleki et al. 1977).

No fish were tagged in 1980 and tagging efforts in 1981-1983 were directed mostly on yellow perch and rock bass because they were the principal species captured by our trap nets. The movements of smallmouth bass were also examined and at least five other species (white bass, white perch, largemouth bass, rainbow trout and walleye) were tagged, but not in sufficient quantity that would provide meaningful recapture information.

Fish were tagged with a numbered T-bar tag inserted between the basal elements of the dorsal rays (Dell 1968). Length (FL and TL to nearest mm) and weight (to nearest g) were measured and a scale sample collected from fish during tagging and when recaptured. In the 1980-1983 period, mean fork lengths of rock bass and yellow perch tagged and released in Long Point Bay were 210 and 198 mm, respectively (Table 3.2.5-1). The results of the age determinations were not available at the time of this writing. Fish recaptured in our trap nets were sampled (length and weight measurements and scale sample) and, if in good condition, were released again and treated as a new tagged fish release. Cash rewards were offered to individuals returning tagged fish with the appropriate recapture information. In addition, a prize was awarded annually by a lottery to one recipient from each of the two fishing groups (commercial and sport fishermen), which had returned one or more tagged fish. Each fish returned served as one entry into the lottery.

Tagged fish releases were classified into four categories:

> Group 1 were fish captured and released at the same location in the Nanticoke area;
>
> Group 2 were fish captured and released (not necessarily at the same location) in the Long Point - Inner Bay area;
>
> Group 3 were fish captured in the Long Point - Inner Bay area and released in the Nanticoke area (including Evan's Point); and

Group 4 were fish captured in the Nanticoke area and released in the Long Point - Inner Bay area (Figure 3.2.5-1).

Group-1 releases apply to the tagging of some 3,400 yellow perch, 4,000 rock bass, and 900 other fish (minor species) during routine sampling of Nanticoke and Centre Creek trap nets (see Section 3.2.1). Up to 40 fish of a species were tagged at each location on the second day (usually Thursday) that trap nets were lifted each week from late April to late October. Tagged fish from this group were released near (approximately 100 m) the same trap net in which they were initially captured. The objective of the Group-1 releases was to identify the major migrations and range of Nanticoke fishes in Long Point Bay during reproductive and non-reproductive periods.

Groups-2, -3 and -4 releases apply to some 4,000 yellow perch tagged during late March and April (spawning season) in 1981 and 1982. Yellow perch from Groups 2 and 3 were captured by commercial hoopnetters in and near the Long Point marsh and some 2000 of each group were released either back into the marsh, or at various locations in and outside Long Point Bay. Fish from Group 4 were captured in trap nets and released (N = 128) near St. Williams in Inner Bay. The objective of the Groups-2, -3 and -4 releases was to monitor the movements of fish to and from spawning areas in Inner Bay and Long Point during reproductive and non-reproductive periods.

Tagged fish returns were separated into 9 release-recapture periods (see table below) based on a spawning season of May 28 to July 13 for rock bass (Carbine 1937) and March 31 to May 21 for yellow perch (Thorpe 1977a, Weber and Les 1982).

| Period | Release-Recapture Definition |
|---|---|
| 1 | released and recaptured before the spawning season in the same year |
| 2 | released before and recaptured during the spawning season in the same year |
| 3 | released before and recaptured after the spawning season in the same year |
| 4 | released and recaptured during the spawning season in the same year |
| 5 | released during and recaptured after the spawning season in the same year |
| 6 | released and recaptured after the spawning season in the same year |
| 7 | recaptured before the spawning season, one or more years after release |
| 8 | recaptured during the spawning season one or more years after release |
| 9 | recaptured after the spawning season one or more years after release |

Periods 1, 2, and 3 were not applicable for yellow perch because perch were tagged and released only during (March 31 - May 21) and after (May 22 - December 31) the spawning season, not before.

Tagged fish releases and recapture data were analysed by SAS programs (SAS Inst. Inc.).

## B. Ultrasonic Telemetry

Yellow perch, rock bass, and smallmouth bass were tracked by ultrasonic telemetry in and near the heated effluent waters of the Nanticoke Thermal Generating Station in 1973-1979. Studies focused on examining movement patterns and diel activity of fish (1973-1974), and on the relationship of fish activity to environmental variables (1975-1977).

Fish were captured in trap nets within 6 km of the generating station and held in aerated tanks at our laboratory in Port Dover or in holding nets in the lake until tagging operations were complete and test fish had regained equilibrium (usually within 1-2 hours of tagging). Initially, transmitters were inserted into the stomach of fish anesthetized with MS-222, but some problems (regurgitation of transmitters and possible adverse physiological effects due to MS-222) were encountered with this technique. Several variations of external attachment on non-sedated fish were tried and the one eventually adopted as the standard was to tie (with dental floss) transmitters onto the dorsal musculature in front of the dorsal fin. This procedure, taking about three minutes to complete, seemed to effect the equilibrium of the fish the least. Only fish 200 mm or larger in total length were used. The average length of test fish during 1975-1977 was 318 mm for smallmouth bass, 235 mm for rock bass, and 279 mm for yellow perch.

Fish were tracked from a boat at a maximum distance of 150 m; most trackings were from a distance of 50 m or less. Three different ultrasonic telemetry systems were used during the 5-year study (see descriptions in MacLean _et al_. 1982). Tracking was done only during daylight after 1974 because previous (1973 and 1974) 24-h trackings showed that fish were largely stationary at night. In 1973, only the hour-by-hour positions of tagged fish were recorded. Thereafter (1974-1977), all trackings were continuous and in finer detail; site information and environmental data measured each time the test fish altered course, included the following: swim speed, angle of turn, distance between turns, light intensity, cloud cover, seechi depth, water depth, turbidity, wave height, surface temperature, current direction and speed, and wind direction and speed.

Tracks made under environmentally different conditions were examined relative to swim speed, angle of turn at course alteration, and distance between turns. An index of the overall level of fish activity was developed based on swim speed and distance between turns. Turn angle was excluded from the activity index because it fluctuated independently of environmental variables. Several models were tried and the one best differentiating individual tracks and providing the highest degree of fit (tested by goodness of fit) with measured levels of environmental variables was an activity index (AI) proportional to the average distance between turns, and to the square root of the average swimming speed. The activity index was made dimensionless by converting the average distances (d) and speeds (S) to fractions of the maximum expected distances ($d_m$) and speed ($S_m$), respectively as follows: $AI = (d/d_m)(S/S_m)^{0.5}$. The maximum values ($d_m$, $S_m$) were extrapolated from observed data. Rationale for using the above activity index is given in MacLean et al. (1982).

## RESULTS

### A. Mark-Recapture

Some 28,000 fish were tagged and released at trapnet locations in Nanticoke from 1971 to 1983 (Table 3.2.5-2). Data reported here describe only the results of our tagging studies since 1981. Of the 8,336 fish tagged during this period (1981-1983), 89% were rock bass and yellow perch. The following analyses pertain mostly to these two species.

Tag recovery rates varied considerably among the principal species captured and released at the Nanticoke trapnet sites from 1981 to 1983 (Table 3.2.5-3). The recovery rate (% recovered of total no. released) was highest for yellow perch (10.2% of 3,416) followed by rock bass (7.4% of 4,021), smallmouth bass (5.7% of 456) and white bass (2.2% of 325). In addition to the standard tagging program, some 3,907 yellow perch were tagged and released at other locations in Long Point Bay in 1981 and 1982 of which 6.0% were recaptured (Table 3.2.5-4).

Most (58.1%) of the tagged rock bass racaptures were recovered by trap nets (Table 3.2.5-5), and this is reflected in the relatively short distances travelled by these fish; more than half (54.3%) of all recaptures occurred within 5 km of the release sites (Figure 3.2.5-2). A substantial number (35% of total recaptures) of rock bass were recovered by anglers, mostly in Inner Bay.

Tagged yellow perch were recovered primarily (65.4% of total recaptures) by commercial small-mesh gill net (Table 3.2.5-5). However, some important differences in recovery methods were apparent among the four release groups for this species. The most notable of these differences were the large percentages of yellow perch returned by anglers (22%) for fish tagged and released at Nanticoke, and by commercial hoopnetters (34.2%) for fish tagged and released in the Long Point - Inner Bay area.

The frequency distribution of distances travelled by tagged fish was skewed right for yellow perch and bimodal for rock bass with peaks occurring at distances of <1 km and 31-35 km from release sites (Figure 3.2.5-5). Frequency of recaptures also declined with time. Most tagged fish (Group-1 releases) were recaptured in the release year (58% of rock bass and 65% of yellow perch recaptures), approximately one-third were recaptured the year after release (34% of rock bass and 32% of yellow perch), and the remainder two to three years after release (Table 3.2.5-3).

### (i) Rock Bass *Group-1 Releases*

During the non-reproductive period (after July 13), rock bass remained within a home area (Figure 3.2.5-3). This was apparent for fish recaptured during and after the release year. Of the 53 tagged rock bass released and recaptured after the spawning season in the release year, 91% were taken at release sites (Table 3.2.5-6 vi). Similarly, of the 32 tagged rock bass recaptured after the spawning season one or more years after release, 50% were taken at release sites (Figure 3.2.5-6 ix). Only 9 tagged rock bass were recaptured in or near Inner Bay during the non-reproductive period (during and after the release year).

During their reproductive period, rock bass migrated some 35-40 km from Nanticoke to Inner Bay (Figure 3.2.5-3). Judging by when tagged rock bass were first recaptured in Inner Bay, the spawning migration probably began as early as 5 weeks before the onset of spawning (approx. the third week of April). A strong along-shore movement during the reproductive period was evident by the large catches of rock bass in trap nets at Nanticoke, which were typically highest in May (Figure 3.2.5-4). A westerly movement alongshore is also suggested by the high frequency of recaptures in the trap nets situated to the west of release locations.

Twenty-nine percent of all rock bass recaptured during the reproductive period in the release year were taken in or near Inner Bay (Figure 3.2.5-3 i, ii, and iv) and an even larger percentage (60%) of recaptures were taken in Inner Bay and vicinity during reproductive periods after the release year (Figure 3.2.5-3 vii and viii).

A return migration of rock bass is suggested by the large numbers (52% of 141) of fish that were recaptured near (5 km or less) release sites one or more years after release (Figure 3.2.5-3 vii to ix). The return migration probably begins shortly after spawning (July and August) as reflected by a decline in angler success rates through the summer in Inner Bay, and a coincident increase in trapnet catches at Nanticoke usually in September (Figure 3.2.5-4).

### (ii) Yellow Perch *Group-1 Releases*

Yellow perch tagged and released at Nanticoke, moved extensively throughout Long Point Bay and beyond during reproductive and non-reproductive periods (Figure 3.2.5-5, Table 3.2.5-7). Movements of yellow perch from Nanticoke to spawning grounds in the Long Point - Inner Bay area were not apparent for fish recaptured in the release year, but were for fish that remained at large for at least one winter. Of the 41 tagged yellow perch recaptured before the spawning season one or more years after release, 93% were taken in Inner Bay mostly by anglers fishing through the ice during January (N = 22) and February (N = 8) (Figure 3.2.5-5 iv). Only three yellow perch were recaptured in Inner Bay during the non-reproductive period (Figure 3.2.5-5 ii, iii, and vi). Mean distances travelled by tagged yellow perch were significantly ($P \leq 0.05$; Tukey's studentized range test) longer during the reproductive period than non-reproductive period (Table 3.2.5-7).

### (iii) Yellow Perch *Group-2 Releases*

Spawning in the marshes and ponds of Long Point by Central Basin yellow perch was evident from returns of tagged fish released in the Long Point - Inner Bay area (Figure 3.2.5-6, Table 3.2.5-8). Some 19 yellow perch travelled from release sites in Inner Bay and Long Point to the Central Basin of Lake Erie. Most (N = 17) of these tag returns were from perch originally captured in Long Point marsh and released in Inner Bay and all (N = 18) but one were recaptured during the non-reproductive period (Figure 3.2.5-6ii to -6 iv). Two tagged yellow perch recovered in the Central Basin originated from Umbrella Pond in Long Point (Figure 3.2.5-6 ii).

Fifty percent of the tagged yellow perch recaptured during the spawning season were recovered within two weeks after their release and several of these fish returned to or near the original capture sites from which they were displaced (Figure 3.2.5-6 i). In particular, two tagged perch released on the south side of Long Point

(Hastings Beach) returned to spawning grounds in the vicinity of Inner Bay either by travelling around the tip of Long Point or through recently formed channels linking the Central Basin with the interior marshes and ponds of Long Point. All of the 50 tagged perch recaptured after the spawning season were recovered outside Inner Bay and offshore of Long Point.

### (iv) Yellow Perch *Group-3 Releases*

Most of the tagged yellow perch displaced along the north shore of Long Point Bay and as far east as Evans Point travelled southwest towards original capture sites in the Long Point-Inner Bay and (Figure 3.2.5-7, Table 3.2.5-9). This movement pattern was particularly evident during the spawning season when nearly half (49%) of the 69 tagged perch recaptured in that period travelled 11 km or more and were taken within 14 days after release (Table 3.2.5-9). One tagged perch in particular travelled 71 km from Evans Point to Long Point Marsh in 9 days (Figure 3.2.5-7 i).

### (v) Yellow Perch *Group-4 Releases*

Of 128 yellow perch captured at Nanticoke and released in Inner Bay during the spawning season, only eight were recaptured; five during and three after the spawning season (Figure 3.2.5-8). All of the tag returns occurred 11 km or more from the release site near St. Williams, mostly along the north shore of Long Point Bay (Table 3.2.5-10).

### (vi) Other Species *Group-1 Releases*

Too few white bass, white perch, and walleye were recaptured to examine their movement patterns.

Of 456 tagged smallmouth bass released at Nanticoke from 1981 to 1983, 26 were recaptured, 12 in the release year and another 14 one or more years after release (Table 3.2.5-3). Although the numbers of recaptures were not large, they indicate a movement of smallmouth bass from Nanticoke to Inner Bay during the reproductive period (May - July) (Figure 3.2.5-9). Approximately 80% (N = 21) of the 26 smallmouth bass recaptured were recovered in the western half of Inner Bay; all were captured by anglers between opening day of bass season (last Saturday in June) and July 21.

### (vii) Effects of Industrial Discharge

The warm water discharge of the Nanticoke Generating Station had no apparent effect on the seasonal movements of rock bass and yellow perch (Table 3.2.5-11). Although the relative numbers of these species released and recaptured at the same location was higher in the NTGS plume trap net than in trap nets receiving little or no thermal discharge, the difference was small (for rock bass: 38.6 versus 31.6%; for yellow perch 13.0 versus 9.5%) and probably insignificant. The percentage of tagged rock bass recaptured at release sites was substantially higher in the Centre Creek nets (81.6%) than in the non-discharge trap nets (31.6%).

### (viii) The Effects of Fishing Activity on Tagged Fish Recoveries

The recovery of tagged fish is influenced by several factors, primarily retention of tags, differential mortality of marked fish, recognition of tags, and movements of tagged fish relative to recovery methods (Wydoski and Emery 1983). The effects of these factors in field studies is difficult to establish and may not always be apparent. In this study, seasonal and spatial variations in fishing activity by sport and commercial fishermen resulted in unequal opportunities for recovery of tagged fish through the year and across the study area. Some important considerations are described below.

Angling in Long Point Bay is concentrated in Inner Bay during July to August in the summer, and January to February in the winter (see Section 3.2.3). Elsewhere in the bay, sport fishing is relatively light except at NTGS where a significant fishery has developed recently (see Section 3.2.4). All tagged rock bass, yellow perch and smallmouth bass recovered in Inner Bay during the summer were by anglers; these waters are closed year-round to commercial trawlers and gill netters, and from May 13 to August 31 to commercial hoop and seine netters.

Smelt trawlers fish through winter if the trawling grounds remain relatively ice-free; however, very few tagged fish are ever returned by trawlers at any time of the year. Consequently, in most years, the on-ice sport fishery, centered near St. Williams is the only efficient tag-recovery fishery active in Long Point Bay during winter. Secondly, duration of the on-ice sport fishery has varied considerably from year to year depending on weather and ice conditions and this in turn has had a direct effect on the numbers of tagged fish (primarily yellow perch) recovered during winter (see table below).

| Year | Approx. No. Days Commercial Ice Huts Were Operated | Est. On-Ice Angling Effort (rod-hours) | Est. No. Yellow Perch Harvested by Anglers | No. tagged Yellow Perch Recovered by Anglers |
|---|---|---|---|---|
| 1982 | 55 | 68,700 | 285,800 | 10 |
| 1983 | 2 | ++ | ++ | 2 |
| 1984 | 58 | 103,858 | 275,954 | 20 |

++ No creel census survey was operated in 1983 because of a brief ice cover period; therefore, estimates of effort and harvest are not available, but probably were small in comparison to the 1982 and 1984 estimates.

During the ice-free period, tagged yellow perch were recovered mostly by commercial gill nets from May to October (Figure 3.2.5-10). Gill nets were not fished during winter and this is reflected by an absence of tagged fish recoveries in outer Long Point Bay from December to February. Most tag recoveries by gill nets were in the areas fished intensively along the fishing reserve boundary and north shore of Long Point Bay (Figure 3.2.5-11). Very few tagged fish were recovered in the offshore waters where gillnet effort was absent or minor.

Tagged rock bass were recaptured primarily in two areas of Long Point Bay by fisheries specific to each area. During the non-reproductive period most tagged rock bass were recaptured in their "home" areas by trap nets. During the spawning season most tagged rock bass were recaptured in Inner Bay by anglers. Surprisingly few tagged rock bass were recovered in the 35-40 km of offshore waters between the release sites at Nanticoke and spawning grounds in Inner Bay. This suggests that rock bass were not susceptible to gill nets, possibly because their movements were along shore in the waters restricted to commerical fishing (see Figure 3.2.5-11). Another possibility is that some tagged rock bass may not have been recognized by gill netters because of this species minor commercial value.

In summary, an absence of tag recoveries at a particular time and place does not necessarily signify an absence of fish, but possibly an absence of suitable effort (in terms of gear efficiency and distribution of effort). The extent to which seasonally and spatially selective recovery efforts biased observations of fish movements in Long Point Bay is not clear.

### B. Ultrasonic Telemetry

Daily movement patterns of rock bass, smallmouth bass, and yellow perch varied considerably among species. All three species were more active during the day than at night. Smallmouth bass were inactive for long periods at a time. When active, their movements consisted of 5- to 10-minute bursts of swimming, usually parallel to shore in water 10 m or less. The movements of rock bass were more localized than those of the other test species, being confined mostly to the release area except during the spring spawning migration (May to June). Due to their sedentary behaviour, rock bass were easily relocated near the site they were last tracked the day before. Rock bass generally stayed in water less than 5 m deep and moved inshore when dusk approached. The movements of yellow perch were sporadic both during the day and night, and usually were most intense in the evening. Smallmouth bass and rock bass often stayed near reefs or large rocks.

They sometimes moved in an erratic zigzag pattern when approaching natural bottom obstacles, gill nets, and trap nets (Figure 3.2.5-12).

Fish released in the plume initially swam against the current, then drifted or swam to a calmer area. Rock bass especially, continued to regularly re-enter the main current and then retreat to calm areas of the plume. Most fish (all species) released in the plume remained there for less than twenty-four hours.

Comparisons of the AI and other measures of activity showed that the behaviour of plume-released fish was significantly different from fish released in control areas (Table 3.2.5-12): the latter group moved farther at faster speeds before changing directions, whereas the movements of fish released in the plume were typically more localized, with sharper turns and shorter distances between turns. Fish that had travelled out of the plume behaved in a manner similar to fish released in control areas.

The influence of environmental variables on fish activity was tested using multiple linear regression and partial correlation analysis. Water column depth, wave height, current speed, temperature, light intensity and turbidity (in order of importance) had the greatest effect on fish activity (species combined). The first four variables were correlated significantly with the AI; combined, they accounted for 14.4% of the variation in AI (Table 3.2.5-13). The remaining seven variables examined accounted for approximately 5% of the total variation in AI. Partial correlation coefficients indicate that the AI for all species combined, increased significantly ($P = 0.05$) with water depth and wave height, but was inversely related to current speed and temperature (Table 3.2.5-14). Significant responses of activity to specific environmental conditions were exhibited as well by individual species (Table 3.2.5-14). The AI of smallmouth bass increased significantly (P = 0.05) with water depth and wave height as did the AI of rock bass with water depth and light intensity. The AI of yellow perch was inversely correlated (P = 0.05) with turbidity and temperature.

## DISCUSSION

### A. Mark-Recapture

By and large, our most recent (1981-1983) observations on fish movements support those described in earlier (1971-1978) tagging studies (Kelso 1973b, MacLean and Teleki 1977, Scrutton and MacLean 1981) and, in addition, provide a better understanding of fish movements in relation to industrial activity at Nanticoke.

With one exception, we examined the tag return information for rock bass in the same way as did MacLean and Teleki (1977) who first reported the homing tendencies of this species in Long Point Bay. Our analyses differed from the former (MacLean and Teleki 1977) in that, in addition to describing tag returns in the release year, we also considered returns acquired after the release year. Except for some minor variations, our results confirmed that during the reproductive period (May to mid-July), rock bass populations along the north shore of Long Point Bay, migrate some 35-40 km to spawning grounds located in the shallow and protected waters of Inner Bay. The spawning migration is probably along shore because several tagged rock bass were recaptured in our Centre Creek trap nets fished close to shore (approximately 100 m off shore) and very few were recovered in the offshore waters fished intensively during this period by commercial gill netters (Figures 3.2.5-10 and -11).

Few field studies of rock bass movements have been conducted on populations inhabiting large lakes and reservoirs, and investigations of stream resident populations (Funk 1955, Brown 1961, Linton and Ball 1965) indicate that this species remains within a restricted home area throughout its entire life. A similar behaviour has been observed among stream and lake dwelling populations of Micropterus and Lepomis spp. (Stone et al. 1954, Hasler and Wisby 1958, Gerking 1959, Kudrna 1967, Rawstron 1967). Our study also has shown that rock bass along the north shore of Long Point Bay are largely sedentary during the non-reproductive period, but migrate 35 km or more to spawning grounds in Inner Bay during May and June each year. However, Storr et al. (1983) observed a much different pattern of movement by rock bass in Lake Ontario. These authors found that tagged rock bass dispersed from release sites over a wide range (as much as 241 km), eventually in a random pattern if fish remained at large for an extended period. Lake Ontario rock bass populations apparently demonstrated little or no orientation toward specific spawning sites.

Our data does not demonstrate clearly whether the rock bass we tagged and released at trapnet sites during the spring migration period originated solely from populations in the Nanticoke area, or also from areas east of Long Point Bay. That only four tagged rock bass out of 239 recaptured were recovered outside Long Point Bay suggests that populations in the bay are largely discrete from other populations in

Lake Erie. However, there may exist very little opportunity for recovery of tagged rock bass along the north shore east of Long Point Bay because commercial gill nets, the principal fishery operating in these waters, were ineffective (3% of all tagged rock bass recaptures) in capturing tagged rock bass (Table 3.2.5-5). Also, sport fisheries in the Canadian waters of Eastern lake Erie outside Long Point Bay are relatively small (see Table 3.2.4-12) and centered near major ports (eg. Gravelly Bay near Port Colborne).

Whether or not rock bass populations along the north shore experience significant exploitation during annual migrations to and from spawning grounds is not known, but we suspect the losses are small for the following reasons. Firstly, rock bass probably are not vulnerable to gill nets because fish movements are thought to be along shore outside the areas fished by commercial gill netters. Secondly, the commercial hoop and seine net fisheries in Inner Bay operate only during the early stages of the spring migration period (these fisheries are closed from May 13 to August 31); therefore, commercial harvests of Nanticoke populations are likely small. Thirdly, rock bass are not highly sought by anglers and, although some 100,000 to 250,000 rock bass are caught each summer by sportsmen, less than one-quarter are kept (Table 3.2.3-4).

Evidence of Nanticoke-released yellow perch spawning in Inner Bay came from tagged fish that remained at large for at least one winter (Figure 3.2.5-5 i). Of the 45 tagged perch recaptured in Inner Bay, all but three were recovered one or more years after release and 90% (38 of 42) of these recaptures were taken before the spawning season while the bay was covered with ice (January - February). The observed winter movements of yellow perch into Inner Bay contrasts to the usual seasonal migration patterns of fish (Harden-Jones 1968, Thorpe 1977b). Typically, as in the case of populations in southeastern Lake Michigan (Wells 1968), yellow perch move into deep water in late fall seeking maximum temperatures of 4°C.

The remaining three tagged perch released at Nanticoke and recaptured in Inner Bay were recovered during October and December in the release year (Figure 3.2.5-5 iii). This suggests that the winter movements of yellow perch into Inner Bay may begin as early as late fall. If such movements occur largely during the winter months, then the perch we tagged late in the spawning season (May) at Nanticoke may be from stocks that spawn in outer Long Point Bay. This premise is supported by an absence of tagged perch recoveries in Inner Bay (from fish initially captured and released at Nanticoke) during the spawning season (Figure 3.2.5-5 i) and by an almost immediate return to Outer Bay waters by perch captured at Nanticoke and released in Inner Bay during the spawning season (Figure 3.2.5-8 i; 5 of 5 recaptures travelled 21 km or more in 13 days or less).

The waters in and around Long Point and Inner Bay are undoubtedly important spawning grounds of yellow perch as evidenced by the return of displaced tagged perch to original spawning sites (Groups-2 and -3 releases; Figures 3.2.5-6i and -7 i, respectively). The fastest movement rates (up to 13 km/day) observed among tagged yellow perch were for fish taken from spawning grounds in the Long Point-Inner Bay area and released along the north shore of Long Point Bay. Some of these fish returned to or near spawning sites (up to 71 km) within a few days of their release. Documented examples of displaced tagged yellow perch returning to exact spawning areas, as we have demonstrated, are relatively uncommon, presumably because few such studies have been attempted. Yellow perch spawners in Oneida Lake, New York reportedly showed a distinct homing tendency (Clady 1977) as did displaced Eurasian perch (Perca fluviatilis) in Lake IJssel, Netherlands (Willemsen 1977).

Yellow perch tagged on spawning beds in the Long Point-Inner Bay area, whether displaced (Group-3 releases) or not (Group-2 releases), dispersed after the spawning season into outer Long Point Bay and the Central Basin, but not into eastern Lake Erie. Yellow perch tagged at Nanticoke during the spawning season eventually dispersed throughout Long Point Bay and along the north shore of eastern Lake Erie as far as the Niagara River. These observations indicate that yellow perch populations spawning in the Long Point-Inner Bay area originated predominately from Long Point Bay and to some extent from central Lake Erie, whereas those spawning in outer Long Point Bay were comprised of local populations and possibly populations from eastern Lake Erie.

Yellow perch, in general, do not travel extensively in unrestricted environments (Thorpe 1977b, Collette et al. 1977). Other studies of lake populations have shown that spring concentrations of yellow perch quickly disperse from spawning areas over a wide region, usually into forage areas in deeper waters (Mraz 1952, Clady 1977, Collette et al. 1977, Schmitt 1981). Yellow perch in the Severn River, Maryland dispersed over the entire river system but not into connecting Chesapeake Bay during the post-spawning period (Muncy 1962).

Alternatively, yellow perch populations in Lake Winnebago, Wisconsin apparently straggled away from spawning beds in river tributaries to feeding areas in the lake over an extended period (Weber and Les 1982). In western Lake Erie, the post-spawning dispersion of yellow perch is so extensive that separation of discrete populations is doubtful (Rawson 1980).

How yellow perch from the Central Basin reach spawning areas in Long Point is not clear. Although we have illustrated the movements of yellow perch between Long Point Bay and the Central Basin as lines extending around Long Point (Figure 3.2.5-6), actual routes travelled by fish were probably via channels recently cut through the south shore of the penninsula and connecting the interior waters of Long Point with the Central Basin. Channelization of Long Point began in the mid-nineteen seventies due to rising lake water levels (pers. comm., D. Dennis) and has permitted ready access by Central Basin yellow perch and possibly other species to spawning grounds in the Long Point area. Mixing of yellow perch populations from Long Point Bay and the Central Basin during spawning seems probable, but to what extent is not known.

Smallmouth bass are largely sedentary in lake (Fraser 1955, Latta 1958, Forney 1961) and stream (Fajen 1962, Reynolds 1965, Munther 1970, Paragamian and Coble 1975) environments, but will travel several kilometers to spawning areas in the spring (Montgomery and Fickeisen 1978), and to "home" areas if displaced (Pflug and Pauley 1983). Although few in number, our observations of smallmouth bass tag recoveries indicate that populations in the Nanticoke area undertake a spawning migration in spring to Inner Bay. Of the 26 smallmouth bass recovered from 1981 to 1983, all but 5 were taken in Inner Bay during or shortly after the spawning season in areas where spawning has been confirmed or is suspected (Reid 1981, Goff 1984, Pynenburg and Witzel 1985).

Previous tagging studies at Nanticoke also have shown a late spring movement of smallmouth bass into Inner Bay with a subsequent return to Outer Bay waters in the fall (Kelso 1973b). Local fishermen have long recognized the seasonal movements of smallmouth bass to and from Inner Bay. Angling success for smallmouth bass typically is best in the first few weeks following opening day (last Saturday in June). Thereafter, angler CUE's declined presumably because bass move into deeper water as water temperatures in Inner Bay rise above their prefered range (Reid 1984b).

Industrial discharges at Nanticoke and Stelco's 1200-m dock (constructed in 1975-1976) had no discernable effect on the seasonal movements of fish along the north shore of Long Point Bay. That our most recent observations taken during the operational period agree closely with those from the earlier studies (commissioning period: 1971-1978) is a good indication that increased industrial discharge at Nanticoke has had no appreciably impact on fish migrations.

Trapnet (Section 3.2.1), gillnet (Section 3.2.2), and angler (Section 3.2.4) catches have demonstrated that fish are attracted to the warm water discharge of the Nanticoke Thermal Generating Station. Attraction to the thermal plume, however, did not seem to greatly extend residency time because tagged fish released in the plume travelled to other areas in about the same relative numbers as did tagged fish released in non-thermal discharge areas at Nanticoke (Table 3.2.5-11). Secondly, fish tracked ultrasonically rarely stayed in the thermal discharge for longer than 24 hours (MacLean et al. 1982).

Why the percentage of tagged rock bass released and recaptured in the same trap net was higher at Centre Creek than elsewhere in the Nanticoke area may be due to increased vulnerability of rock bass to the Centre Creek nets. The seasonal movement patterns characteristic of rock bass (along-shore spawning migration in spring and localized inshore movements during the non-reproductive period) probably increased their chances of recapture in the shallower set Centre Creek trap nets.

### B. Ultrasonic Telemetry

Observations of nocturnal movement patterns indicate reduced activity by yellow perch, rock bass, and smallmouth bass in comparison to daylight movements. Emery (1973) also found that smallmouth bass and rock bass rested on bottom at night and that yellow perch, while still active during darkness, moved more slowly at night than during the day. Hergenrader and Hasler (1967) observed decreased activity by yellow perch at night, whereas Helfman (1979) observed very little movement by perch at night.

Our observations of increased AI by smallmouth bass with increased wave height and water depth are supported by Teleki et al. (1977) who observed that smallmouth bass moved to deeper water in response to wind-induced turbulence. Disturbance of the inshore waters also may explain why rock bass were more active in deeper water. Decreased activity by yellow perch during conditions of increased turbidity may be due to reduced visual acuity (Ali et al. 1977). Consequently, fluctuations in wave turbulence and turbidity in response to ever changing wind conditions likely have an important effect on the day-to-day activity patterns of yellow perch and other species.

Although water depth accounted for more of the variation in AI than all the other variables combined, it probably was not a factor contributing to the observed differences in fish behaviour between plume and control locations as water depth was equally important (approximately 10% of the variation on AI) in both areas. Wave height, current speed and temperature also had significant effects on fish activity and it may be these variables that contributed the most to behavioural differences between plume and control fish (Table 3.2.5-14). Water temperatures and currents were higher in the plume than control area, and wave height generally was lower in the plume because of a dock which sheltered the discharge area from the prevailing westerly winds. Correlations of these three variables with AI indices were not significant at either location. Correlation coefficients were much lower for plume than for control trackings (Table 3.2.5-14), possibly because environmental conditions within the plume were more constant than the surrounding lake.

Current undoubtedly was an important factor influencing fish behaviour in the plume as shown by the rheotactic response in many of the trackings. Kelso (1976) also reported that fish respond mainly to current when encountering the NTGS plume. Minns et al. (1978) concluded that turbulence regimes and lake bottom relief, rather than temperature, were the main causes of fish congregating in the plume. All three species demonstrated significantly less activity in the plume than in areas outside the thermal influence. However, this behavioural difference is not a true indication of the energy expenditure by fish in the outfall, as energy is required simply to maintain position in the current.

The effect of temperature on fish activity is unclear even though it accounted for 1.6% of the variation in the AI (Table 3.2.5-13). All species travelled to and from the plume, remaining in the heated discharge usually for no longer than twenty-four hours. Coutant (1975) found that the response of fish to thermal gradients varied with length of exposure time and that temperature gradients larger than 4-5°C usually were avoided. That fish apparently were attracted to the warm water discharge of the Nanticoke Thermal Generating Station, but did not remain there for long periods, suggests that environmental conditions in the plume were not constant from day to day. Coutant (1975) reported that largemouth bass tracked in a spring-fed quarry selected the warmest water available in spring and remained in a preferred range of temperatures as the surface temperatures increased. Another study concluded that striped bass (Morone saxatilis) selected water depths in their preferred thermal range, but also selected temperatures outside this range for short periods (Coutant and Carroll 1980). The attraction of fish to the NTGS plume also may have been due to an abundance of food organisms (Storr and Schlenker 1974).

The heated discharge of the NTGS appears to attract fish, but does not interfere with their spawning migrations (MacLean and Teleki 1977). Fish may be delayed for a short time (usually <24 hours), but no long term residency was noted in this study or in Kelso's (1976). Despite differences in behaviour of fish in the plume and in areas unaffected by the heated discharge, no adverse effects on fish entering or leaving the outfall were observed. Fish that moved from the plume to waters outside the thermal area behaved similar to control fish.

## C. Summary

The importance of Inner Bay as a spawning/nursery area for fish populations in and even outside Long Point Bay was evident from our most recent mark and recapture studies. We have shown, as in the earlier studies, that rock bass undertake a 35-40 km migration each spring from Nanticoke to spawning beds in Inner Bay, but during the non-reproductive period they remain in a localized home area restricting their movements to 5 m of water or less.

In addition to the regular tagging program at Nanticoke, yellow perch were collected from spawning grounds in Long Point and Inner Bay in the spring and released at various locations in and outside Long Point Bay. These supplementary tagging efforts resulted in several important findings. Displaced perch returned to spawning sites in the Long Point-Inner Bay area during the spawning season. But, during the non-reproductive period, Long Point-Inner Bay spawning populations dispersed throughout Long Point Bay and to some extent into the Central, but not the Eastern Basin. Perch populations from the

Central Basin spawned in selected inland (marshes and ponds) waters of Long Point and, therefore, likely interbreed with populations from Long Point Bay.

Yellow perch tagged and released late in the spawning season at trapnet locations in Nanticoke did not demonstrate a distinct movement toward Inner Bay in the release year, but did during subsequent winters. Apparently, yellow perch moved into Inner Bay during the ice cover period several weeks (as much as 3 months) before the spawning season. Many Nanticoke-released perch were recovered near the north shore of eastern Lake Erie suggesting that there is some mixing of populations between Long Point Bay and the Eastern Basin.

Ultrasonic tracking showed that a significant amount of fish movement during the non-reproductive period was due to environmental factors, primarily water depth and temperature, wave height, and current. Fish movements in the plume were primarily in response to current and not temperature. The activities of plume-area fish differed significantly from control-area fish in that the movements of the former group were more localized, with sharper turns and shorter distances between turns.

Although fish were attracted to the NTGS outfall they neither stayed in the warm water plume for extended periods nor were their spawning migrations disrupted by it.

Sport and commercial fishing effort in Long Point Bay was variable both spatially and temporally and may have biased observations of tagged fish recaptures. However, these factors did not diminish the validity of individual tag recoveries but, rather, resulted in an incomplete description of where tagged fish were at a particular time and place.

Table 3.2.5-1. Mean fork length (FL, mm) and body weight (wt, g) of tagged fish at first capture and at recapture for each of the principal capture methods, Long Point Bay, 1981-1983.

| METHOD † OF CAPTURE | STATISTIC | SIZE AT FIRST CAPTURE | | SIZE AT RECAPTURE | |
|---|---|---|---|---|---|
| | | FL | WT | FL | WT |
| | | **ROCK BASS** | | | |
| Trap net | Mean | 210 | 244 | 207 | 222 |
| | SD | 32.7 | 98.1 | 36.4 | 94.9 |
| | N | 4111 | 4069 | 152 | 163 |
| Angling | Mean | | | 221 | 249 |
| | SD | | | 23.3 | 84.5 |
| | N | 0 | 0 | 40 | 39 |
| Comm.<br>Gill net | Mean | | | 213 | 212 |
| | SD | | | 22.1 | 60.2 |
| | N | 0 | 0 | 7 | 7 |
| Comm<br>Hoop net | Mean | | | 215 | 253 |
| | SD | | | 14.1 | 29.0 |
| | N | 0 | 0 | 2 | 2 |
| | | **YELLOW PERCH** | | | |
| Trap net | Mean | 196 | 119 | 208 | 137 |
| | SD | 49.8 | 104.1 | 31.5 | 73.2 |
| | N | 3544 | 3511 | 34 | 34 |
| Angling | Mean | | | 228 | 200 |
| | SD | | | 40.3 | 139.3 |
| | N | 0 | 0 | 33 | 36 |
| Comm.<br>Gill net | Mean | | | 204 | 123 |
| | SD | | | 28.0 | 59.3 |
| | N | 0 | 0 | 217 | 230 |
| Comm.<br>Hoop net | Mean | 200 | 121 | 216 | 136 |
| | SD | 22.8 | 52.2 | 26.8 | 49.8 |
| | N | 3764 | 3362 | 44 | 42 |
| Comm<br>Seine net | Mean | | | 225 | 175 |
| | SD | | | 41.2 | 123.1 |
| | N | 0 | 0 | 8 | 9 |
| Comm.<br>Trawl | Mean | | | 198 | 106 |
| | SD | | | 14.6 | 24.5 |
| | N | 0 | 0 | 6 | 6 |
| | | **SMALLMOUTH BASS** | | | |
| Trap net | Mean | 265 | 403 | 323 | 500 |
| | SD | 81.8 | 689.2 | -- | -- |
| | N | 460 | 460 | 1 | 1 |
| | | **WHITE BASS** | | | |
| Trap net | Mean | 181 | 135 | 166 | 75 |
| | SD | 28.8 | 532.2 | -- | -- |
| | N | 350 | 350 | 1 | 1 |
| Comm.<br>Gill net | Mean | | | 208 | 184 |
| | SD | | | 59.2 | 181.3 |
| | N | 0 | 0 | 3 | 3 |
| | | **WHITE PERCH** | | | |
| Trap net | Mean | 157 | 65 | | |
| | SD | 23.1 | 23.8 | | |
| | N | 105 | 104 | 0 | 0 |

† Trap nets refer to those fished by the OMNR; commercial gill net refers to small mesh (2.125 - 3.0 in.) net fished specifically for yellow perch; commercial hoop and seine nets refer to the fisheries in the Long Point - Inner Bay area; commercial trawl refers to the rainbow smelt trawl fishery.

Table 3.2.5-2. Numbers of fish tagged each year during the regular trapnetting program (Group-1 releases) at Nanticoke, Long Point Bay, from 1971-1983.

| Species Tagged | No. of Fish Released by Year[*] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1971[+] | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1981 | 1982 | 1983 |
| Rock Bass | 25 | 0 | 0 | 988 | 502 | 1993 | 1445 | 906 | 1030 | 1916 | 1075 |
| Yellow Perch | 473 | 3665 | 546 | 2010 | 282 | 686 | 1143 | 517 | 1087 | 1526 | 803 |
| White Bass | 470 | 578 | 145 | 60 | 34 | 42 | 16 | 159 | 26 | 230 | 69 |
| Smallmouth Bass | 789 | 533 | 207 | 250 | 58 | 118 | 117 | 171 | 69 | 329 | 58 |
| White Perch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 20 | 83 |
| Walleye | 22 | 0 | 129 | 46 | 3 | 1 | 4 | 18 | 5 | 5 | 1 |
| Other[++] | 64 | 91 | 0 | 365 | 28 | 169 | 33 | 10 | 0 | 2 | 0 |
| TOTAL | 1843 | 4867 | 1027 | 3719 | 907 | 3009 | 2758 | 1781 | 2219 | 4028 | 2089 |

[*] 1971-1978 data taken from Hamley (1981).

[+] Includes 3 nets set in September 1972 specifically to catch salmonids (Kelso 1972).

[++] Includes 49 northern pike in 1971, 88 coho salmon in 1972, 107 pumpkinseed, 92 freshwater drum, and 76 white sucker in 1974, 19 crappies (Black and white) in 1975, 129 freshwater drum in 1976, 27 freshwater drum in 1977, 8 freshwater drum in 1978.

Table 3.2.5-3. Numbers of tagged fish recaptured each year during the regular trapnetting program (Group-1 releases) at Nanticoke, Long Point Bay, 1981-1983.

| | | No. of tagged fish of the specified kind recaptured by recapture year | | | | |
|---|---|---|---|---|---|---|
| Release Year | No. Released | 1981 | 1982 | 1983 | 1984 | Total |
| | | **ROCK BASS** | | | | |
| 1981 | 1030 | 35 | 38 | 10 | 2 | 85 |
| 1982 | 1916 | | 92 | 46 | 10 | 148 |
| 1983 | 1075 | | | 45 | 18 | 63 |
| TOTAL | 4021 | 35 | 130 | 101 | 30 | 296 |
| | | **YELLOW PERCH** | | | | |
| 1981 | 1087 | 105 | 62 | 7 | 0 | 174 |
| 1982 | 1526 | | 73 | 23 | 3 | 99 |
| 1983 | 803 | | | 48 | 28 | 76 |
| TOTAL | 3416 | 105 | 135 | 78 | 31 | 349 |
| | | **SMALLMOUTH BASS** | | | | |
| 1981 | 69 | 0 | 0 | 1 | 0 | 1 |
| 1982 | 329 | | 10 | 11 | 1 | 22 |
| 1983 | 58 | | | 2 | 1 | 3 |
| TOTAL | 456 | 0 | 10 | 14 | 2 | 26 |
| | | **WHITE BASS** | | | | |
| 1981 | 26 | 0 | 0 | 0 | 0 | 0 |
| 1982 | 230 | | 6 | 0 | 0 | 6 |
| 1983 | 69 | | | 0 | 1 | 1 |
| TOTAL | 325 | 0 | 6 | 0 | 1 | 7 |

Table 3.2.5-4. Numbers of tagged yellow perch recaptured each year from the supplementary (Group-2, -3, and -4 releases) tagging programs in Long Point Bay, 1981-1982.

| Release Group | Capture/Release Description | Release Year | No. Released | No. of Yellow Perch Recaptured by Recapture Year | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 1981 | 1982 | 1983 | 1984 | Total |
| 2 | Captured and released in the Long Point - Inner Bay area | 1981 | 570 | 33 | 8 | 0 | 0 | 41 |
| | | 1982 | 1370 | | 72 | 3 | 1 | 76 |
| | | TOTAL | 1940 | 33 | 80 | 3 | 1 | 117 |
| 3 | Captured in the Long Pt.- Inner Bay area and released in the Nanticoke area | 1981 | 550 | 34 | 3 | 0 | 0 | 37 |
| | | 1982 | 1289 | | 68 | 5 | 0 | 73 |
| | | TOTAL | 1839 | 34 | 71 | 5 | 0 | 110 |
| 4 | Captured in the Nanticoke area and released in the Long Pt. - Inner Bay area | 1982 | 128 | | 8 | 0 | 0 | 8 |

Table 3.2.5-5. Percentages of the total number of tagged rock bass and yellow perch recaptured in commercial, sport, and experimental gear for the various tagging programs operated in Long Point Bay, 1981-1983.

| Release Group | Capture/Release Description | Total No. of Recaptures | Commercial Gear | | | | Sport Gear | Nanticoke and Centre Creek Trap Nets | Other Gear |
|---|---|---|---|---|---|---|---|---|---|
| | | | Gill Net | Smelt Trawl | Seine Net | Hoop Net | | | |
| | **ROCK BASS** | | | | | | | | |
| 1 | Captured and released at Nanticoke/Centre Cr. trap nets | 296 | 3.0 | 0.0 | 0.7 | 2.4 | 35.0 | 58.1 | 0.7 |
| | **YELLOW PERCH** | | | | | | | | |
| 1 | (Same as above) | 346 | 63.6 | 2.3 | 2.3 | 0.9 | 22.0 | 9.0 | 0.0 |
| 2 | Captured and released in the Long Point - Inner Bay area | 117 | 56.4 | 0.0 | 0.0 | 34.2 | 8.5 | 0.0 | 0.9 |
| 3 | Captured in the Long Pt. - Inner Bay area and Released in the Nanticoke area | 110 | 80.0 | 0.0 | 2.7 | 5.5 | 6.4 | 5.5 | 0.0 |
| 4 | Captured in the Nanticoke area and released in the Long Pt. - Inner Bay Area | 8 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1-4 | All release groups | 581 | 65.4 | 1.4 | 1.9 | 8.4 | 16.2 | 6.4 | 0.2 |

Table 3.2.5-6. Aspects of rock bass movements from Group-1 releases for nine release-recapture periods based on May 28 to July 13 spawning season, 1981-1983.

| RELEASE-RECAPTURE PERIOD No. | RELEASE-RECAPTURE PERIOD Description | Reference Component of Fig. 3.2.5-3 | No. of Recaptures | No. of Days After Release to 50% Recaptures | % of Recaptures That Travelled the Distances (km) Specified | | | | Mean Distance Travelled (km) | Mean Displacement Rate (km/day) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0 | 1-5 | 6-10 | >10 | | |
| 1 | Released and recaptured before the spawning season in the same year | i | 33 | 7 | 55 | 12 | 15 | 18 | 7.6 | 0.824 |
| 2 | Released before and recaptured during the spawning season in the same year | ii | 37 | 25 | 32 | 0 | 11 | 57 | 22.6 | 0.719 |
| 3 | Released before and recaptured after the spawning season in the same year | iii | 5 | 80 | 0 | 0 | 20 | 80 | 29.0 | 0.453 |
| 4 | Released and recaptured during the spawning season in the same year | iv | 27 | 7 | 48 | 19 | 7 | 26 | 8.3 | 0.967 |
| 5 | Released during and recaptured after the spawning season in the same year | v | 16 | 53.5 | 31 | 25 | 13 | 31 | 17.0 | 0.358 |
| 6 | Released and recaptured after the spawning season in the same year | vi | 53 | 15 | 91 | 2 | 2 | 6 | 1.4 | 0.055 |
| 7 | Recaptured before the spawning season one or more years after release | vii | 34 | 254 | 29 | 21 | 12 | 38 | 14.0 | 0.050 |
| 8 | Recaptured during the spawning season one or more years after release | viii | 54 | 359 | 6 | 7 | 7 | 80 | 27.4 | 0.046 |
| 9 | Recaptured after the spawning season one or more years after release | ix | 32 | 387 | 50 | 22 | 3 | 25 | 19.3 | 0.040 |
| | Totals and Means | | 291 | 51.5 | 43 | 11 | 8 | 38 | 15.1 | 0.333 |

Table 3.2.5-7. Aspects of yellow perch movements from Group-1 releases for six release-recapture periods based on March 31 to May 21 spawning season, 1981-1983.

| RELEASE-RECAPTURE PERIOD | | Reference Component of Fig. 3.2.5-5 | No. of Recaptures | No. of Days After Release to 50% Recaptures | % of Recaptures That Travelled the Distances (km) Specified | | | | Mean Distance Travelled (km) | Mean Displacement Rate (km/day) |
|---|---|---|---|---|---|---|---|---|---|---|
| No. | Description | | | | 0 | 1-5 | 6-10 | >10 | | |
| 4 | Released and recaptured during the spawning season in the same year | i | 28 | 5 | 25 | 36 | 11 | 29 | 17.2 | 1.500 |
| 5 | Released during and recaptured after the spawning season in the same year | ii | 102 | 69 | 11 | 13 | 33 | 43 | 14.9 | 0.281 |
| 6 | Released and recaptured after the spawning season in the same year | iii | 88 | 40 | 14 | 19 | 23 | 44 | 13.3 | 0.543 |
| 7 | Recaptured before the spawning season one or more years after release | iv | 41 | 241 | 0 | 0 | 0 | 100 | 37.7 | 0.256 |
| 8 | Recaptured during the spawning season one or more years after release | v | 44 | 330 | 0 | 11 | 16 | 73 | 19.8 | 0.071 |
| 9 | Recaptured after the spawning season one or more years after release | vi | 35 | 410 | 0 | 20 | 37 | 43 | 16.3 | 0.041 |
| | Totals and Means | | 338 | 97 | 9 | 15 | 23 | 53 | 17.4 | 0.446 |

Table 3.2.5-8. Aspects of yellow perch movements from Group-2 releases for five release-recapture periods based on March 31 to May 21 spawning season, 1981-1983.

| RELEASE-RECAPTURE PERIOD | | Reference Component of Fig. 3.2.5-6 | No. of Recaptures | No. of Days After Release to 50% Recaptures | % of Recaptures That Travelled the Distances (km) Specified | | | | Mean Distance Travelled (km) | Mean Displacement Rate (km/day) |
|---|---|---|---|---|---|---|---|---|---|---|
| No. | Description | | | | 0 | 1-5 | 6-10 | >10 | | |
| 4 | Released and recaptured during the spawning season in the same year | i | 58 | 13.5 | 0 | 29 | 34 | 36 | 13.0 | 1.136 |
| 5 | Released during and recaptured after the spawning season in the same year | ii, iii | 44 | 78 | 0 | 2 | 18 | 80 | 26.0 | 0.402 |
| 7 | Recaptured before the spawning season one or more years after release | iv | 1 | 663 | 0 | 100 | 0 | 0 | 4.0 | 0.006 |
| 8 | Recaptured during the spawning season one or more years after release | iv | 4 | 238 | 0 | 75 | 0 | 25 | 6.3 | 0.079 |
| 9 | Recaptured after the spawning season one or more years after release | iv | 6 | 461.5 | 0 | 0 | 50 | 50 | 15.7 | 0.031 |
| | Totals and Means | | 113 | 31 | 0 | 19 | 27 | 53 | 17.8 | 0.740 |

Table 3.2.5-9. Aspects of yellow perch movements from Group-3 releases for five release-recapture periods based on March 31 to May 21 spawning season, 1981-1983.

| RELEASE-RECAPTURE PERIOD |  | Reference Component of Fig. 3.2.5-7 | No. of Recaptures | No. of Days After Release to 50% Recaptures | % of Recaptures That Travelled the Distances (km) Specified |  |  |  | Mean Distance Travelled (km) | Mean Displacement Rate (km/day) |
|---|---|---|---|---|---|---|---|---|---|---|
| No. | Description |  |  |  | 0 | 1-5 | 6-10 | >10 |  |  |
| 4 | Released and recaptured during the spawning season in the same year | i | 69 | 14 | 10 | 7 | 33 | 49 | 16.0 | 1.646 |
| 5 | Released during and recaptured after the spawning season in the same year | ii | 21 | 125.5 | 0 | 0 | 19 | 81 | 28.8 | 0.309 |
| 7 | Recaptured before the spawning season one or more years after release | iii | 1 | 335 | 0 | 0 | 0 | 100 | 36.0 | 0.107 |
| 8 | Recaptured during the spawning season one or more years after release | iii | 2 | 386 | 0 | 0 | 0 | 100 | 28.5 | 0.075 |
| 9 | Recaptured after the spawning season one or more years after release | iii | 3 | 443 | 33 | 0 | 0 | 67 | 13.0 | 0.030 |
|  | Totals and Means |  | 96 | 24 | 8 | 5 | 28 | 58 | 19.1 | 1.234 |

Table 3.2.5-10. Aspects of yellow perch movements from Group-4 releases for two release-recapture periods based on March 31 to May 21 spawning season, 1982.

| RELEASE-RECAPTURE PERIOD |  | Reference Component of Fig. 3.2.5-8 | No. of Recaptures | No. of Days After Release to 50% Recaptures | % of Recaptures That Travelled the Distances (km) Specified |  |  |  | Mean Distance Travelled (km) | Mean Displacement Rate (km/day) |
|---|---|---|---|---|---|---|---|---|---|---|
| No. | Description |  |  |  | 0 | 1-5 | 6-10 | >10 |  |  |
| 4 | Released and recaptured during the spawning season in the same year | i | 5 | 9 | 0 | 0 | 0 | 100 | 25.6 | 2.651 |
| 5 | Released during and recaptured after the spawning season in the same year | ii | 3 | 125 | 0 | 0 | 0 | 100 | 56.7 | 0.512 |
|  | Totals and Means |  | 8 | 11.5 | 0 | 0 | 0 | 100 | 37.3 | 1.849 |

Table 3.2.5-11. Percent of tagged rock bass and yellow perch recaptured in trap nets at Nanticoke and other locations in Long Point Bay in the release year, 1981-1983. Recapture data were summarized into three trap net release areas: areas receiving thermal discharge (NTGS Plume), chemical discharge (Centre Creek), and little or no direct industrial discharge (non-discharge).

| | | PERCENT OF TOTAL TAGGED FISH RECOVERED AT THE SPECIFIED LOCATIONS | | |
|---|---|---|---|---|
| RELEASE LOCATION | NO. RECAPTURED | RELEASE TRAP NET | OTHER++ TRAP NET | OTHER* LOCATIONS |
| | | ROCK BASS | | |
| Centre Creek Trap Nets | 76 | 81.6 | 7.9 | 10.5 |
| NTGS Plume Trap Nets | 57 | 38.6 | 5.3 | 56.1 |
| Non-Discharge+ Trap Nets | 38 | 31.6 | 34.2 | 34.2 |
| | | YELLOW PERCH | | |
| Centre Creek Trap Nets | 58 | 15.5 | 1.7 | 82.7 |
| NTGS Plume Trap Nets | 69 | 13.0 | 1.4 | 85.5 |
| Non-Discharge+ Trap Nets | 74 | 9.5 | 4.1 | 86.5 |

+ Trap nets which received minimal or no industrial discharge: East Brown's Point, West Brown's Point, Oneida, Peacock Point, and Selkirk.

++ Trap nets which recovered tagged fish released at other trapnet locations.

* Tagged fish recovery locations other than trap nets.

Table 3.2.5-12. Comparison of fish activity in plume and control areas (mean values of 1975-1977 data). After MacLean et al. 1982.

| | SMALLMOUTH BASS | | | ROCK BASS | | | YELLOW PERCH | | |
|---|---|---|---|---|---|---|---|---|---|
| **MEASURE OF ACTIVITY** | **Plume** | **Control** | **t** | **Plume** | **Control** | **t** | **Plume** | **Control** | **t** |
| Activity index | 0.025 | 0.124 | 4.06* | 0.017 | 0.139 | 4.4* | 0.018 | 0.155 | 2.74* |
| Dist. betw. turns (m) | 50 | 170 | 5.10* | 37 | 173 | 4.26* | 46 | 213 | 3.08* |
| Turn angle (°) | 2 | 9 | 0.85 | -4 | 8 | 3.06* | 7 | 9 | 1.05 |
| Swimming speed (cm/s) | 8.3 | 14.4 | 1.99 | 5.1 | 16.1 | 4.35* | 7.4 | 20.0 | 2.38* |
| N | 14 | 6 | | 8 | 7 | | 8 | 6 | |

*Difference between means statistically (t-statistic) significant at P=0.05.

Table 3.2.5-13. Multiple linear regression analyses of the Activity Index with six environmental variables (% = %-variation in Activity Index due to the variable; 1975-1977 data, combining all tracks). After MacLean _et al_. 1982.

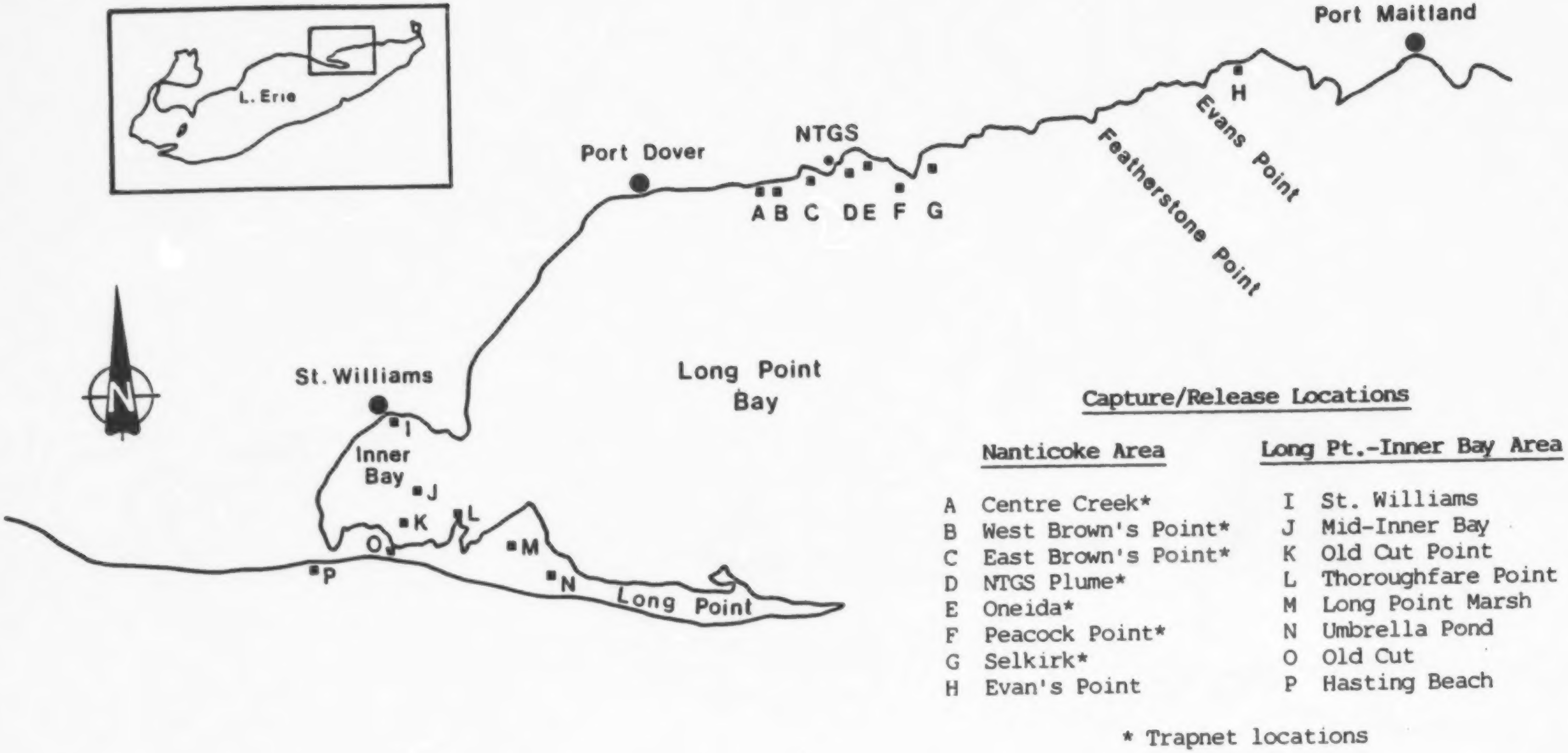
| ENVIRONMENTAL VARIABLE | % | F |
|---|---|---|
| Water depth | 9.45 | 37.32* |
| Wave height | 1.67 | 6.61* |
| Current speed | 1.62 | 6.41* |
| Temperature | 1.61 | 6.41* |
| Light intensity | 0.08 | 0.32 |
| Turbidity | 0.04 | 0.16 |
| All variables | 19.51 | 12.84* |

* Variation (F-statistic) significant at P=0.05.

Table 3.2.5-14. Partial correlation coefficients between the Activity Index and six environmental variables (1975-1977 data combined). After MacLean et al. 1982.

| **ENVIRONMENTAL VARIABLE** | **LOCATIONS COMBINED** | | | **SPECIES COMBINED** | | |
|---|---|---|---|---|---|---|
| | **Smallmouth Bass** | **Rock Bass** | **Yellow Perch** | **Plume** | **Control** | **ALL TRACKS** |
| Water depth | 0.332* | 0.489* | 0.015 | 0.290* | 0.329* | 0.324* |
| Wave height | 0.276* | 0.150 | 0.078 | -0.018 | 0.141 | 0.143* |
| Current speed | -0.083 | -0.036 | -0.038 | -0.051 | -0.112 | -0.141* |
| Temperature | -0.038 | -0.163 | -0.249* | -0.008 | -0.149 | -0.140* |
| Light intensity | 0.003 | 0.227* | 0.036 | -0.099 | 0.099 | -0.032 |
| Turbidity | 0.129 | -0.022 | -0.272* | 0.049 | 0.026 | 0.022 |

* Correlation coefficient significant at P = 0.05 .



L. Erie
N
Port Maitland
H
Evans Point
Featherstone Point
NTGS
Port Dover
A B C DE F G
Long Point Bay
St. Williams
I
Inner Bay
J
K
L
M
N
O
P
Long Point

Capture/Release Locations

| Nanticoke Area | | Long Pt.-Inner Bay Area | |
|---|---|---|---|
| A | Centre Creek* | I | St. Williams |
| B | West Brown's Point* | J | Mid-Inner Bay |
| C | East Brown's Point* | K | Old Cut Point |
| D | NTGS Plume* | L | Thoroughfare Point |
| E | Oneida* | M | Long Point Marsh |
| F | Peacock Point* | N | Umbrella Pond |
| G | Selkirk* | O | Old Cut |
| H | Evan's Point | P | Hasting Beach |

* Trapnet locations

Figure 3.2.5-1. Locations where fish were originally captured, tagged and released in Long Point Bay and area in 1981-1983.

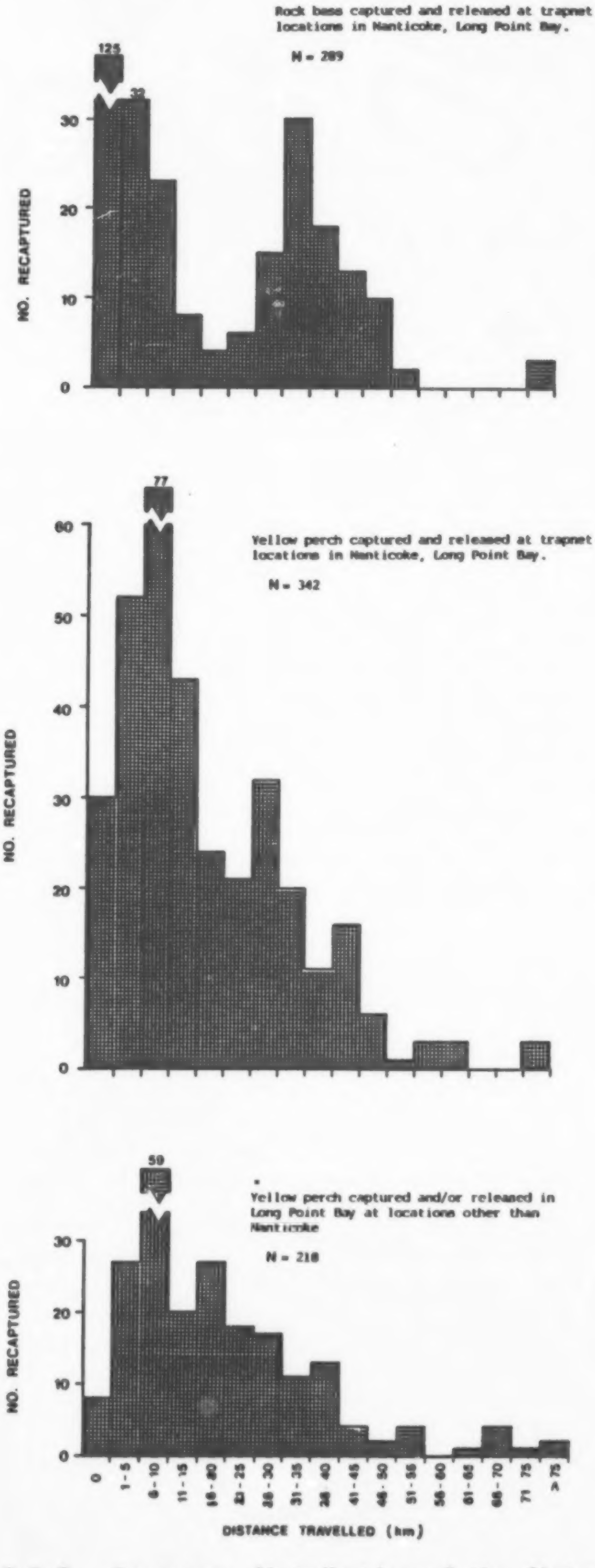
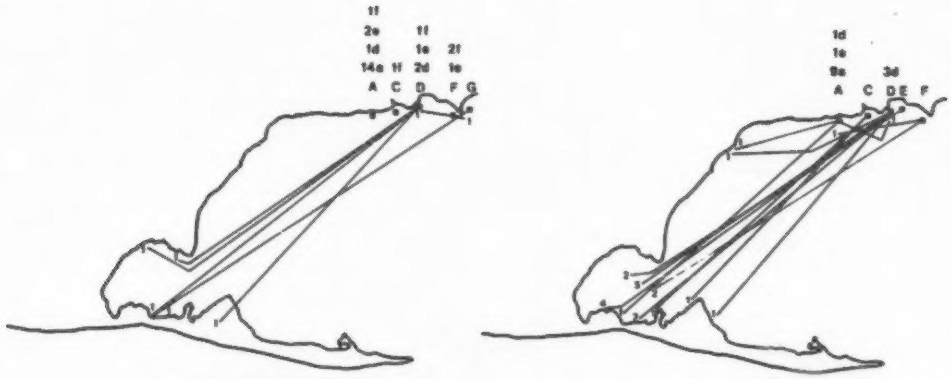
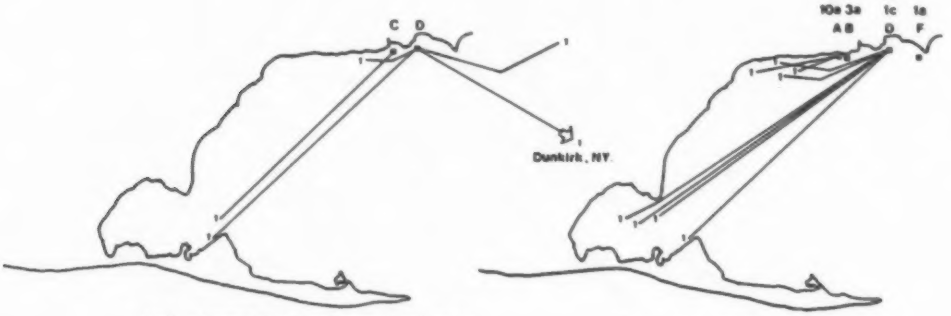


Figure 3.2.5-2. Frequency distribution of the distances travelled by tagged rock bass and yellow perch released at Nanticoke and other locations in Long Point Bay, 1981-1983.


1f
2e
1d
14a
A
1f
C
1f
1e
2d
D
2f
1e
F
G
1d
1e
9a
A
C
3d
D
E
F

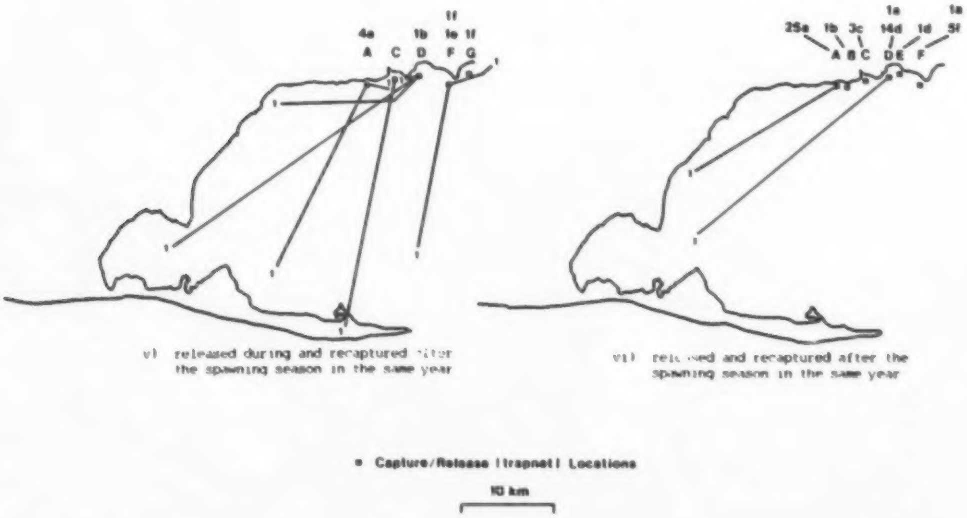
i) released and recaptured before the spawning season in the same year

ii) released before and recaptured during the spawning season in the same year.


C
D
Dunkirk, NY
1b
10a
3a
A
B
3d
1c
D
1a
F

iii) released before and recaptured after the spawning season in the same year

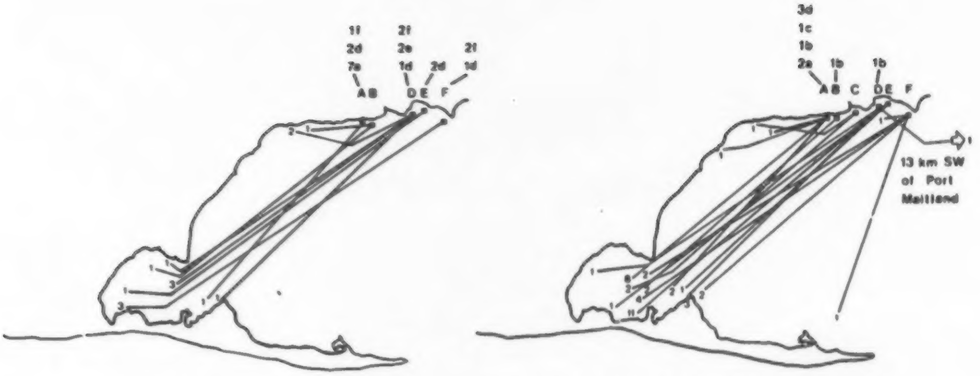
iv) released and recaptured during the spawning season in the same year


4a
A
C
1b
D
1f
1e
F
1f
G
25a
A
1b
B
3c
C
1a
14d
D
1d
E
1a
5f
F
● Capture/Release (trapnet) Locations
10 km

v) released during and recaptured after the spawning season in the same year

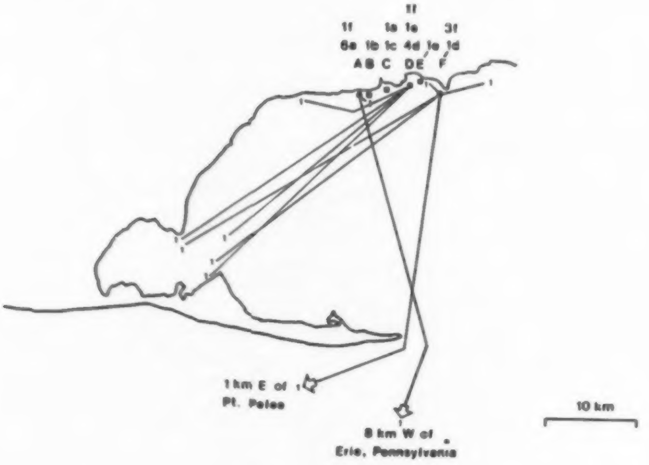
vi) released and recaptured after the spawning season in the same year

Figure 3.2.5-3. Rock bass recaptures from Group-1 releases (captured and released at Nanticoke and Centre Creek trap nets) for release-recapture periods based on May 28 to July 13 spawning season, 1981-1983. Trapnet locations are represented by capital letters A to G (see Figure 3.2.5-1). Superscripts above trapnet locations denote the numbers of rock bass recaptured and their release locations.


1f
2d
7a
A B
2f
2e
1d
2d
2f
1d
D E F
3d
1c
1b
2a
1b
1b
A B C D E F
13 km SW
of Port
Maitland

vii) recaptured before the spawning season one or more years after release

viii) recaptured during the spawning season one or more years after release


1f
1f 1a 1e 3f
6a 1b 1c 4d 1e 1d
A B C D E F
1 km E of
Pt. Pelee
8 km W of
Erie, Pennsylvania
10 km

ix) recaptured after the spawning season one or more years after release

Figure 3.2.5-3. Continued...

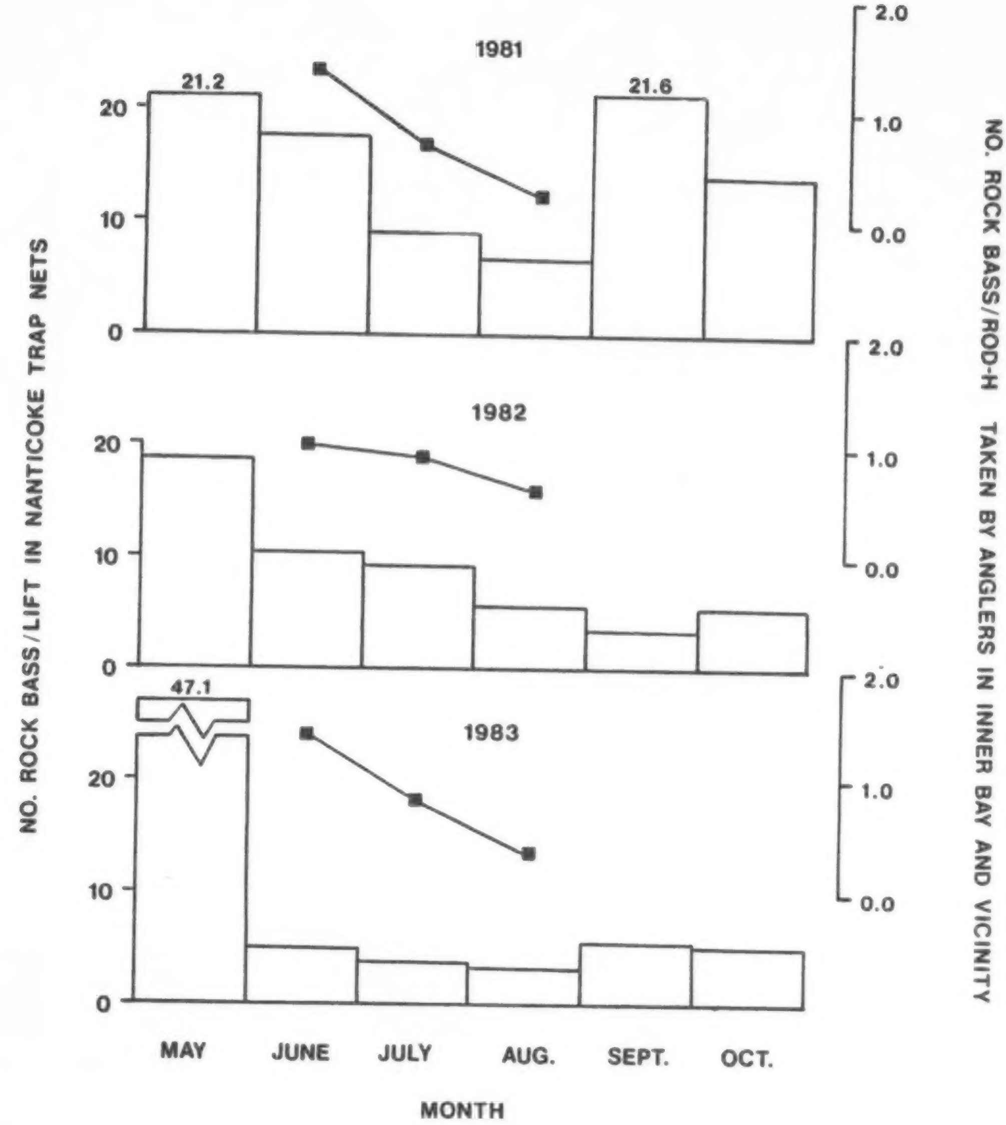
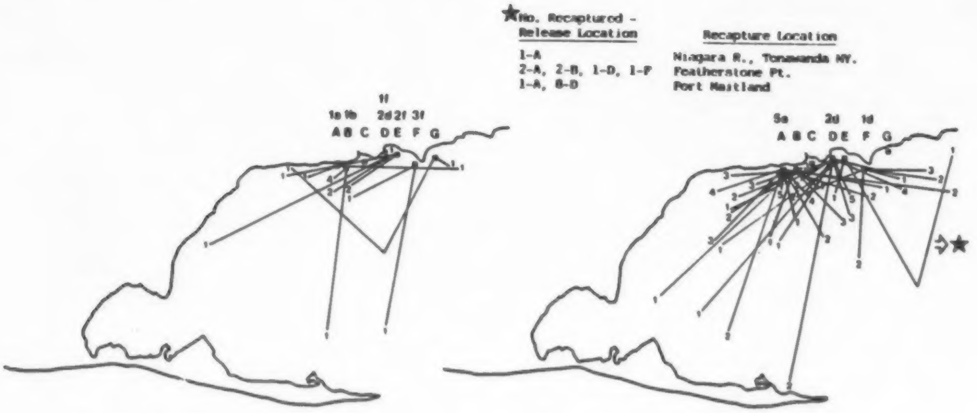
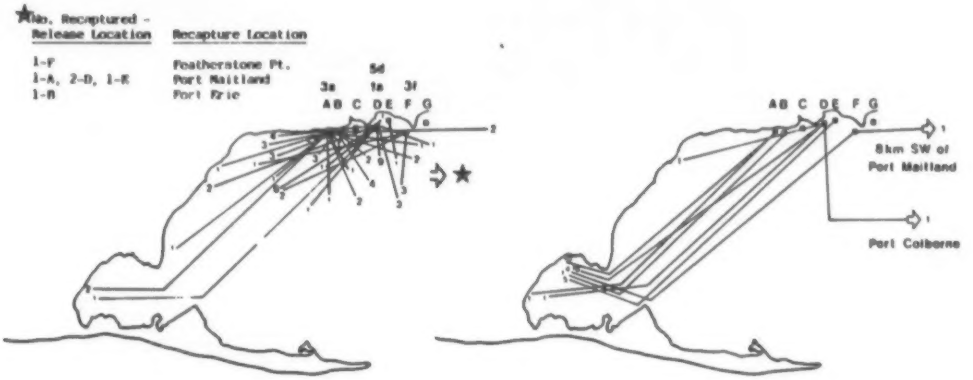


Figure 3.2.5-4. Monthly indicies of rock bass abundance at Nanticoke (trap nets) and in Inner Bay (angler CUE's), 1981-1983.


★No. Recaptured -
Release Location
Recapture Location
1-A
Niagara R., Tonawanda NY.
2-A, 2-B, 1-D, 1-F
Featherstone Pt.
1-A, 8-D
Port Maitland
1f
1a 1b 2d 2f 3f
A B C D E F G
5a 2d 1d
A B C D E F G
★

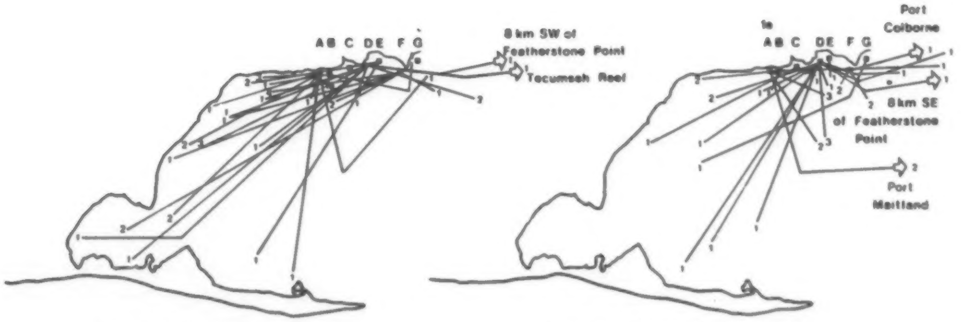
i) released and recaptured during the spawning season in the same year

ii) released during and recaptured after the spawning season in the same year


★No. Recaptured -
Release Location
Recapture Location
1-F
Featherstone Pt.
1-A, 2-D, 1-E
Port Maitland
1-B
Port Erie
5d
3a 1a 3f
A B C D E F G
★
A B C D E F G
8km SW of Port Maitland
Port Colborne

iii) released and recaptured after the spawning season in the same year

iv) recaptured before the spawning season one or more years after release


A B C D E F G
8 km SW of Featherstone Point
Tecumseh Reef
1a
A B C D E F G
Port Colborne
8 km SE of Featherstone Point
Port Maitland
10 km

v) recaptured during the spawning season one or more years after release

vi) recaptured after the spawning season one or more years after release

Figure 3.2.5-5. Yellow perch recaptures from Group-1 releases (captured and released at Nanticoke and Centre Creek trap nets) for release-recapture periods based on March 31 to May 21 spawning season, 1981-1983. Trapnet locations are represented by capital letters A to G (see Figure 3.2.5-1). Superscripts above trapnet locations denote the numbers of rock bass recaptured and their release locations.

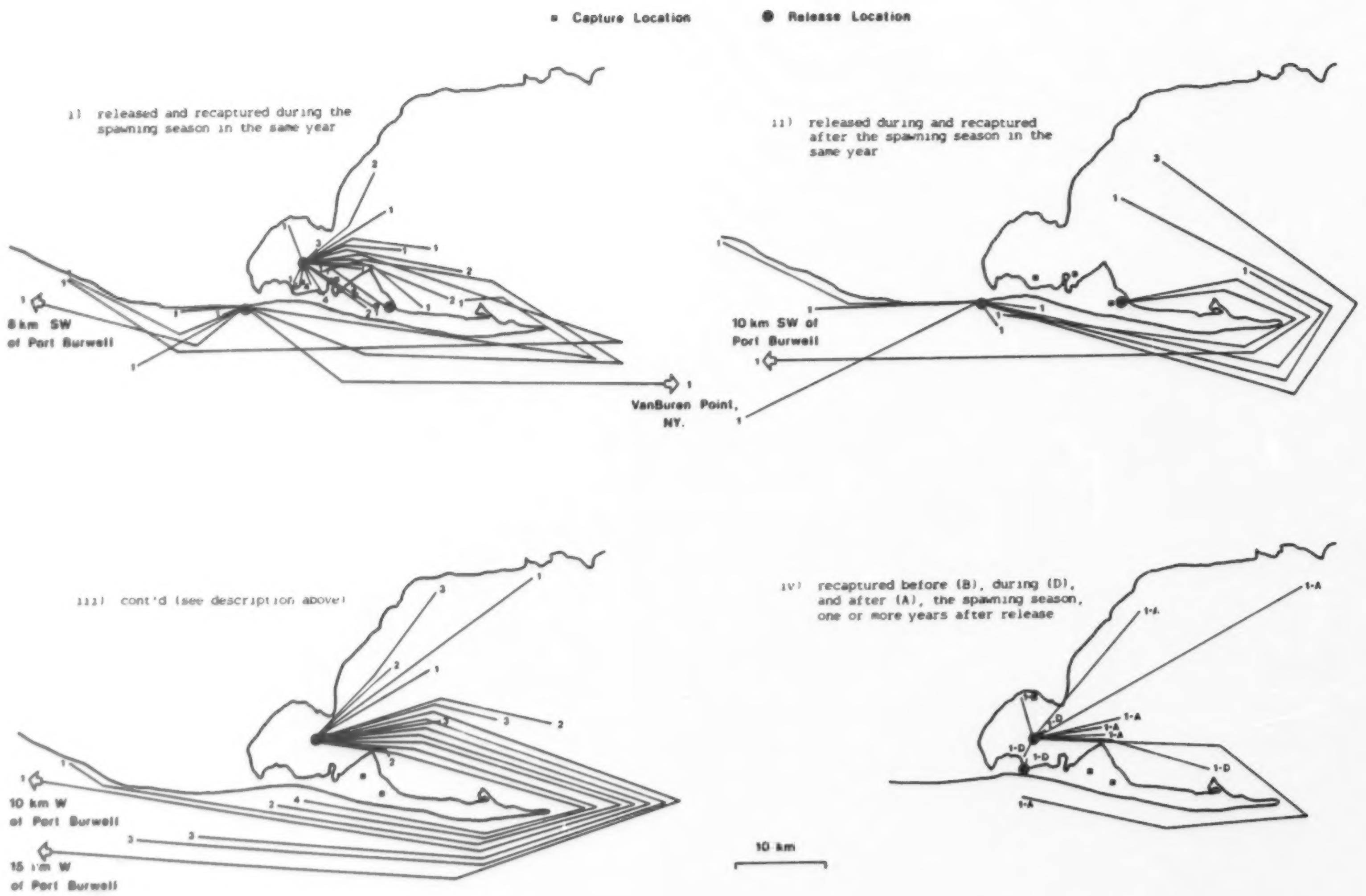
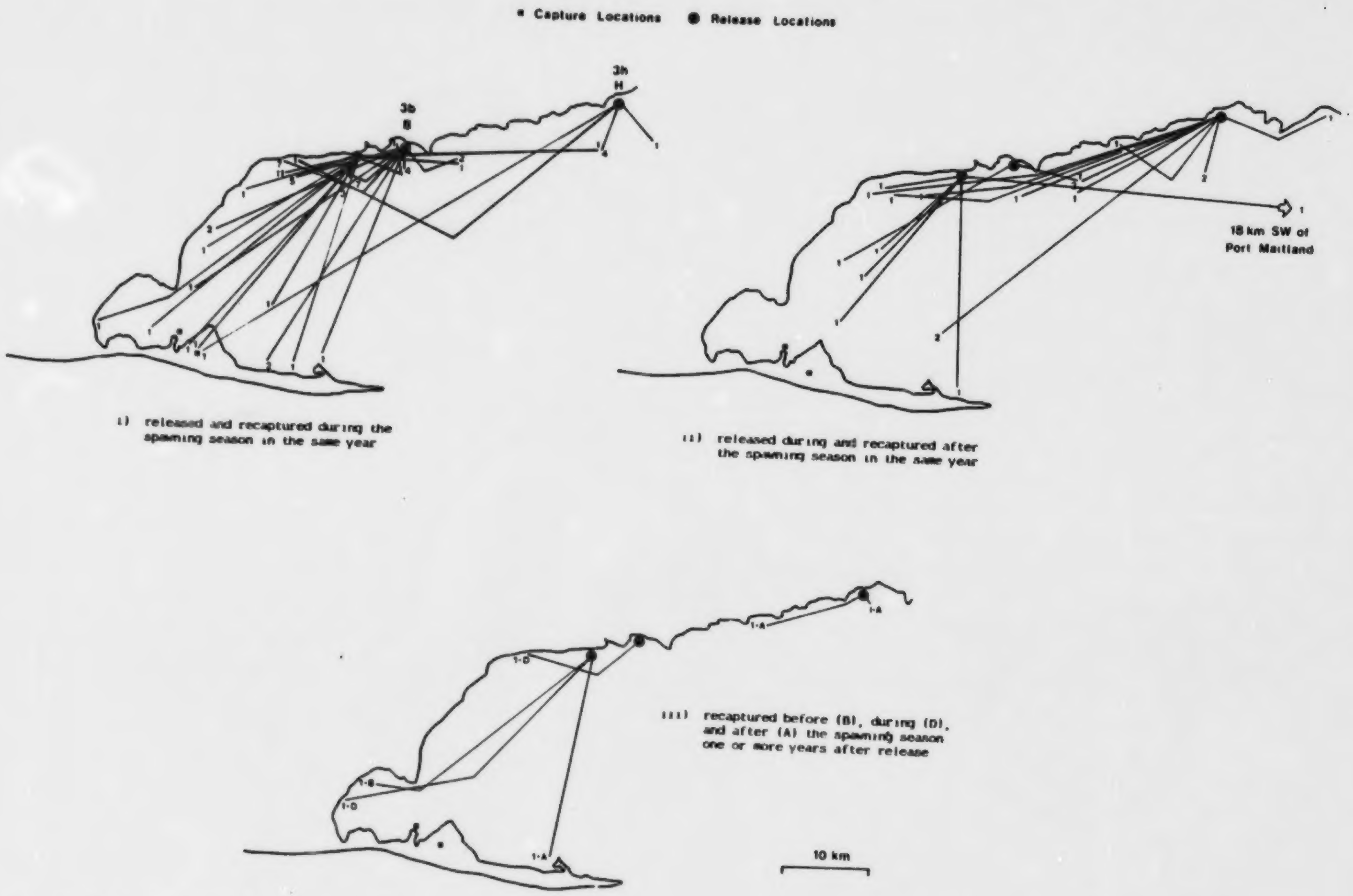

▪ Capture Location
● Release Location
i) released and recaptured during the spawning season in the same year
8 km SW of Port Burwell
VanBuren Point, NY.
ii) released during and recaptured after the spawning season in the same year
10 km SW of Port Burwell
iii) cont'd (see description above)
10 km W of Port Burwell
15 km W of Port Burwell
iv) recaptured before (B), during (D), and after (A), the spawning season, one or more years after release
10 km

Figure 3.2.5-6. Yellow perch recaptures from Group-2 releases (captured and released in the Long Point-Inner Bay area) for release-recapture periods based on March 31 to May 21 spawning season 1981-1983.

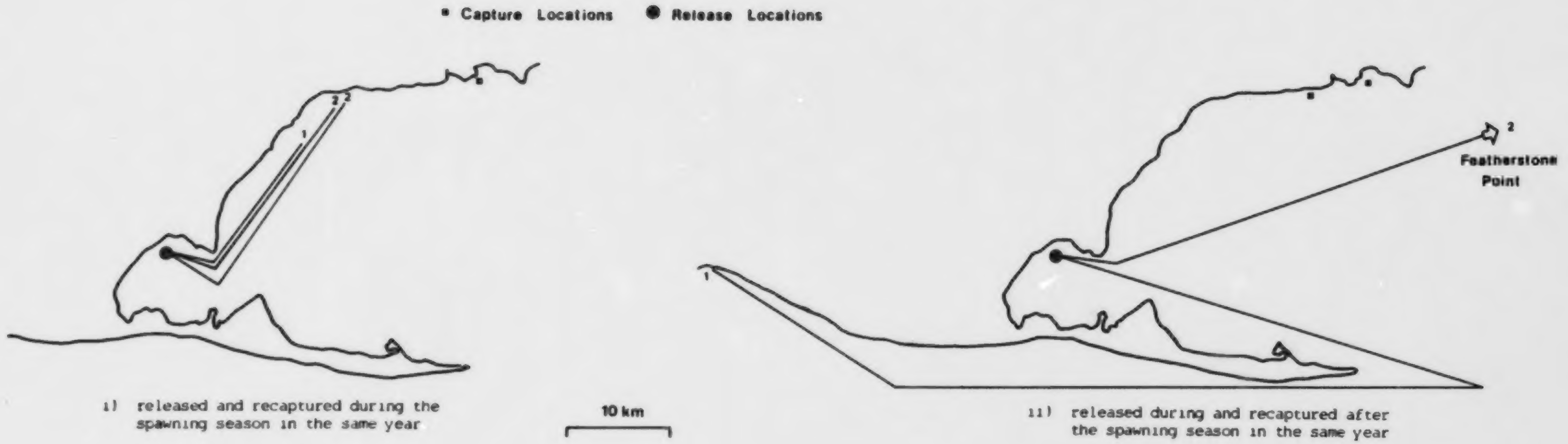

Capture Locations
Release Locations
3b
B
3h
H
18 km SW of Port Maitland
10 km

i) released and recaptured during the spawning season in the same year

ii) released during and recaptured after the spawning season in the same year

iii) recaptured before (B), during (D), and after (A) the spawning season one or more years after release

Figure 3.2.5-7. Yellow perch recaptures from Group-3 releases (captured in the Long Point-Inner Bay area and released in the Nanticoke area) for release-recapture periods based on March 31 to May 21 spawning season, 1981-1983. Superscripts above release location denote numbers of yellow perch recaptured at that location (see Figure 3.2.5-1).


▪ Capture Locations
● Release Locations
10 km
1
2
2
1
2
Featherstone Point

i) released and recaptured during the spawning season in the same year

ii) released during and recaptured after the spawning season in the same year

Figure 3.2.5-8. Yellow perch recaptures from Group-4 releases (captured in the Nanticoke area and released in the Long Point-Inner Bay area) for release-recapture period based on March 31 to May 21 spawning season, 1982.

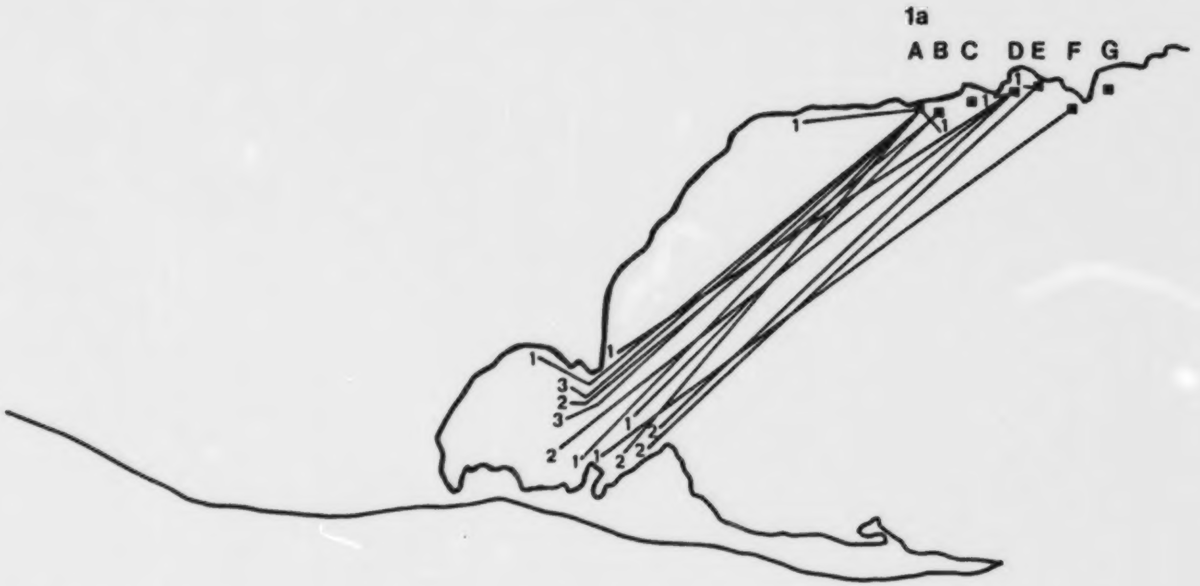


Figure 3.2.5-9. Smallmouth bass recaptures from Group-1 releases (captured and released at Nanticoke and Centre Creek trap nets), 1981-1983. Trapnet locations are represented by capital letters A to G (see Figure 3.2.5-1). Superscripts above trapnet locations denote the numbers of smallmouth bass recaptured and their release locations.

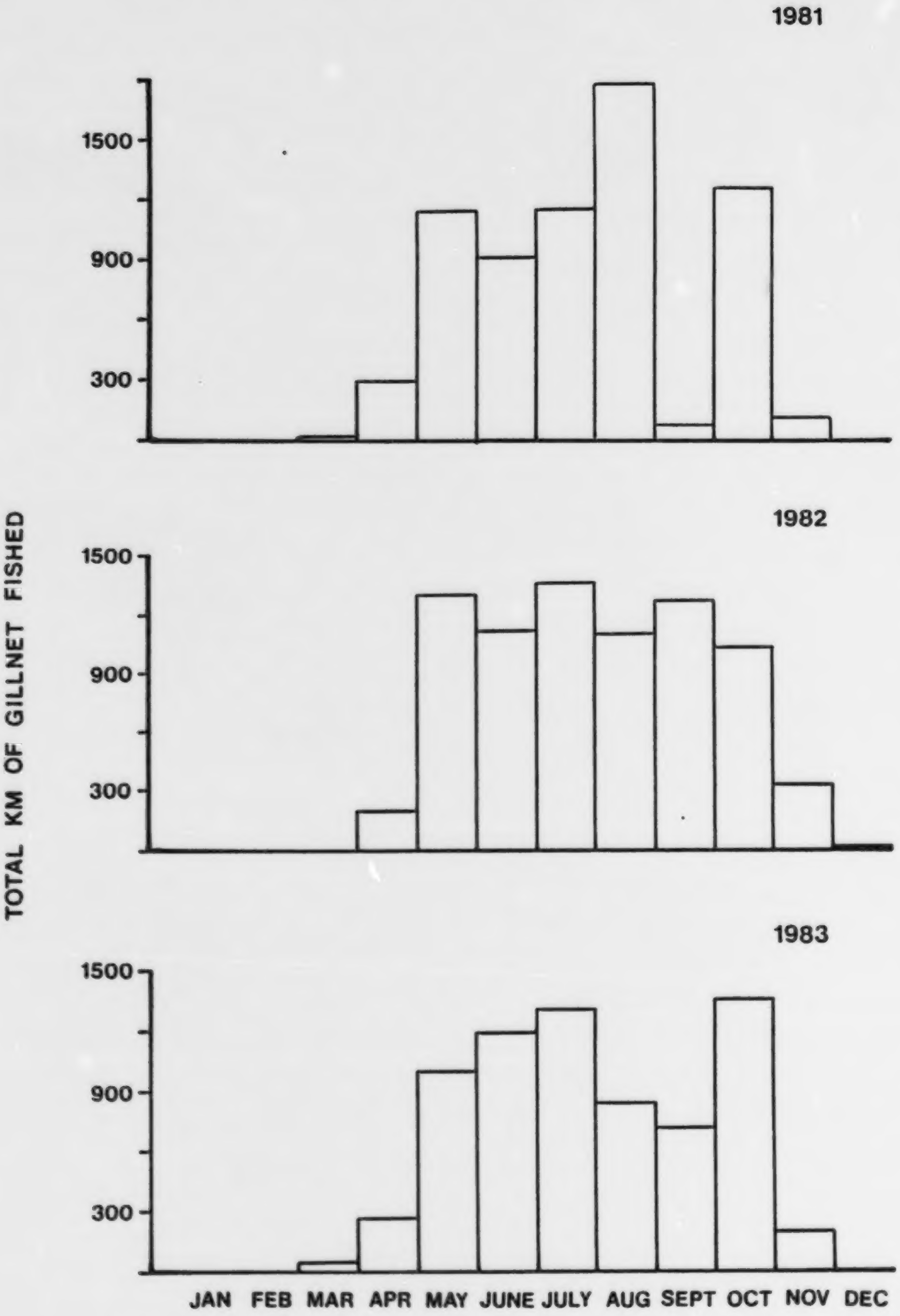


Figure 3.2.5-10. Monthly total km of small-mesh (2.125 - 3.0 in.) gill net fished in Long Point Bay and vicinity (pooled grids in Figure 3.2.5-11), 1981-1983.

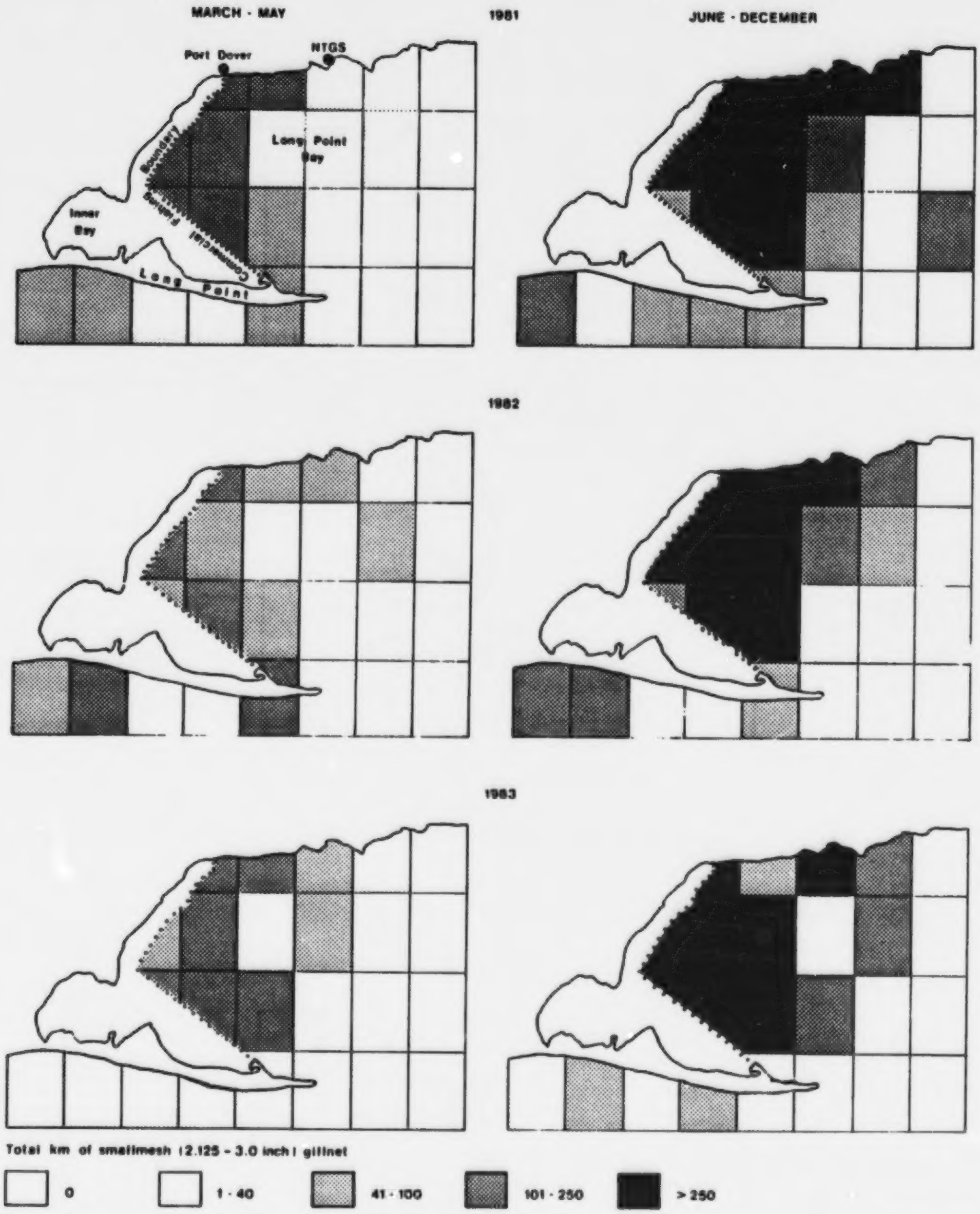

MARCH - MAY
1981
JUNE - DECEMBER
Port Dover
NTGS
Long Point Bay
Inner Bay
Boundary
Eastward
Commercial
Long Point
1982
1983
Total km of smallmesh (2.125 - 3.0 inch) gillnet
0
1 - 40
41 - 100
101 - 250
> 250

Figure 3.2.5-11. Distribution of commercial small-mesh (2.125 - 3.0 in.) gillnet effort in Long Point Bay and vicinity, 1981-1983.

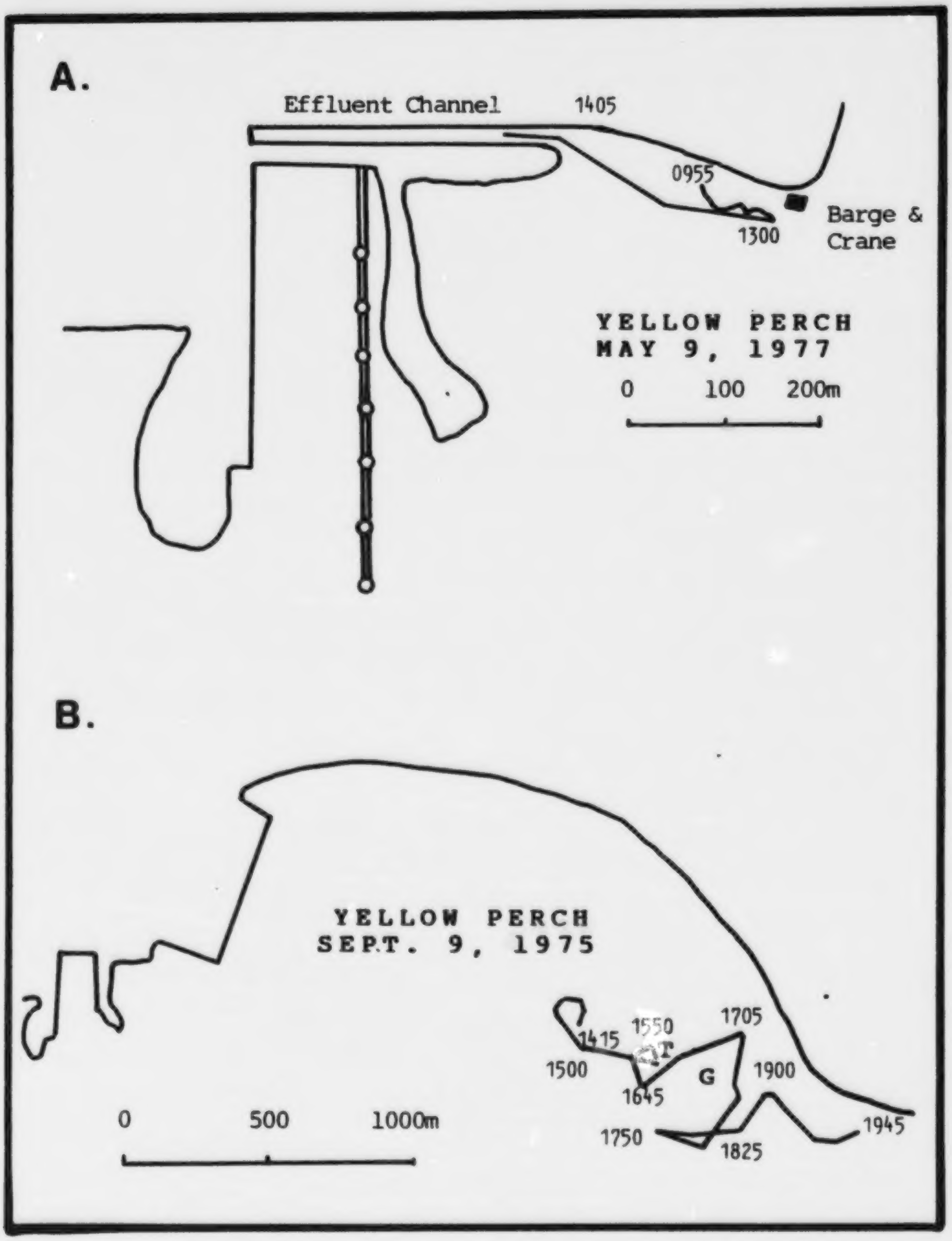

A.
Effluent Channel
1405
0955
1300
Barge &
Crane
YELLOW PERCH
MAY 9, 1977
0
100
200m
B.
YELLOW PERCH
SEPT. 9, 1975
1415
1550
1705
T
1500
G
1900
1645
0
500
1000m
1750
1825
1945

Figure 3.2.5-12. Examples of tracks to illustrate avoidance behaviour. **A.** Zig-zag movement and reversal of direction near construction activity. **B.** Avoidance of a trapnet T and a gill net G (numbers beside tracks show times a day). After MacLean et al. 1982.

## 3.3 GENERAL DISCUSSION AND SUMMARY

A principal objective of the fish studies at Nanticoke was to monitor the abundance, distribution and composition of the fish community in Long Point Bay relative to industrial development along the north shore since the early 1970's. Our study area was concentrated in the nearshore waters fronting Nanticoke where the effects of industrial discharges presumably would be the greatest.

An optimal design for long term monitoring studies such as the one undertaken at Nanticoke requires that observed changes in fish populations unique to the impact area be identified and separated from fluctuations due to natural environmental factors and other man-induced stresses (such as sport and commercial fisheries) unrelated to industry (Green 1978). However, as natural fluctuations in year-class strengths were so large, and effects of commercial and recreational exploitation on the abundance of Long Point Bay fish populations so strong, it became clear only extensive impacts attributable to industry would be detectable unless our sampling design was expanded beyond our capabilities.

In addition, long term monitoring necessitates adherance to standard procedures that will yield testable results. In this regard, virtually every component of our fish studies experienced some degree of change in methodology, primarily during the earlier years. The temptation to improve sampling methods arose from unforeseen logistical, technical and analytical problems realized after an initial period of direct experience. Some of the procedural changes were of minor consequence. Major changes were rationalized on the basis that it was better to initiate a change and subsequently omit a couple of years of data, but have improved indices for the remaining survey period, than to generate a continuous series of untestable indices. In retrospect, some of the inconsistencies could have been avoided had prior knowledge of spatial and temporal variability in fish abundance been available and our understanding of the life history of fish populations within the Nanticoke area been more complete. The first few years of monitoring, in effect, became a pilot study for ironing-out procedural difficulties.

Studies of fish abundance, distribution and composition at Nanticoke have consisted of three long-term monitoring programs: a larval fish sampling program and trap and gill netting programs selective for primarily adult fish. In addition, we assessed in 1982 and 1983, the sport fishery on the heated outfall of the Nanticoke TGS, and over a much longer period (1971 - 1983) the sport fishery centered in Inner Bay. We examined the migration patterns of selected fishes by mark-recapture methods and details of their local movements (particularly in the NTGS discharge area) by ultrasonic telemetry.

Each of three major monitoring programs utilized different gears and methods, and each described a different component of the fish community near Nanticoke because of the selectivity characteristics (eg. net size, mesh size) unique to each gear and because of how, when, and where they were fished. Tow net catches of larval fish consisted of only a few species, mostly rainbow smelt (91% of total catch), which were rarely caught as adults in trap nets or gill nets except in smallmesh gill nets (25-38 mm stretched measure) fished specifically for this species during a special study to describe their distribution in the Nanticoke Generating Station thermal discharge during spawning (see Section 4.2). Our trap nets captured some 30 or more species, mostly rock bass and yellow perch (combined >60% of total catch). Gill nets also captured a variety of species (approx. 26 taxa), but the catch was dominated by alewife (2-88% of annual total catch) and gizzard shad (2-83% of total catch) in surface sets, and by yellow perch (51-92% of annual total catch) in bottom sets.

None of the long term monitoring programs showed any clear evidence that industry had adversely impacted the fish populations at Nanticoke. The most significant effect of industry on fish abundance/distribution was the attraction of fish to the thermal discharge of the Nanticoke TGS. A notable sport fishery has developed on the thermal discharge as a direct consequence of adult fish concentrating in these waters. Despite evidence of spawning by smelt and an abundance of zooplankton (first food of larval fish) in the discharge area, we did not find that larval smelt were more abundant in the thermal discharge than elsewhere. But, this may have been the result of inadequate sampling and/or because the spatial distribution of the size classes of larval fish most vulnerable to our tow nets was determined more by passive (wind and lake currents) than active (selection of prefered habitat) factors.

The effects of gear selectivity and habitat variation on fish catches were most apparent at the Nanticoke TGS plume. Trap nets and gill nets were fished in the peripheral areas of the thermal discharge because high flow velocities did not permit us positioning them directly in the current near the discharge outfall. The two trap nets we fished in the plume in 1982 and 1983 captured primarily rock bass and yellow perch, but not in equal numbers or sizes. The West Plume trap net, which had slightly smaller mesh (2.0 versus 2.5 in.) in some of its components (heart, wings and funnel), captured significantly more, but smaller perch and rock bass than did the East Plume net. The West Plume trap net, in most years since 1975, captured more fish than did the other standard trapnet locations, which received little (Oneida, Peacock Pt.) or no (East and West Brown's Pt.) thermal discharge.

Similarly, gill nets in the plume captured more fish than those at a reference site; however, the composition of gillnet catches (at both the plume and reference locations) was much different from trapnet catches and varied between surface and bottom sets. As expected, pelagic feeding species like alewife, gizzard shad, and white bass occurred most frequently in surface catches, whereas demersal feeders such as yellow perch, rock bass, smallmouth bass and freshwater drum were taken most frequently near the lake bottom. Not surprisingly, white bass - a pelagic species - were neither prominent in trapnet catches nor bottom-set gillnet catches. Yet this species was obviously abundant in the thermal discharge channel during the spawning period (mid-May to early June) as evidenced by their prominence in angler catches. White bass presumably concentrated in the discharge channel and near the outfall, and to a lesser extent near the surface in the peripheral areas of the plume.

Variability in catches of most species were highly significant across years, seasons, and locations. In particular, larval fish catches were so non-uniformly distributed that we were forced to compromise statistical analysis of even the most abundant species to (rainbow smelt) non-parametric examinations of presence versus absence.

We attributed most of the location-to-location variability in adult fish catches (trap and gill nets) to habitat variation. The aforementioned attraction of fish to the warm water discharge from the Nanticoke Generating Station is the best example of this effect.

Seasonal variations in trapnet and gillnet catches were due primarily to seasonal movement patterns and activity levels of the major species. Trapnet catches of yellow perch and rock bass typically were highest in spring during the period of spawning migrations. Significant alongshore migrations of rock bass and smallmouth bass from Nanticoke to Inner Bay were observed during spring. Yellow perch also moved extensively during spring, but they tended to disperse from release sites at Nanticoke over a much wider range than did rock bass and smallmouth bass. Gear selectivity was also a factor explaining seasonal variability in catches. For example, yellow perch generally recruited into the 8-ft trap nets as 2 year olds late in the growing season (late summer to fall).

We were particularly interested in examining indices of year-to-year fish abundance for possible trends related to industrial development, but found none. We did, however, find a close relationship between annual variations in trapnet catches of yellow perch at Nanticoke and variations in stock size of yellow perch in Eastern Lake Erie. We were unable to demonstrate a similar relationship in most other species because of insufficient age composition data, and because stock size indices were unavailable except for yellow perch. There were, however, some indications that trap- and gillnet catches at Nanticoke reflected the relative status of some minor species lakewide. For example, our nets showed the new presence of white perch (in 1981) and a dramatic increase in catches of gizzard shad (in 1983) in the same years these phenomena were observed by the commercial fishery throughout Lake Erie.

Some of the day-to-day variability in catches of adult fishes, which we were unable to account for in our main parametric analyses (eg. ANOVA), we attributed to environmental factors. Trapnet (yellow perch, rock bass), gillnet (yellow perch, gizzard shad), and angler (white bass and smallmouth bass) catches of the more frequently captured species were statistically correlated with water temperature, indicating that distribution patterns (spatial and temporal) and activity levels of fish were influenced by this variable. Variations in the volume of water discharged from the NTGS apparently influenced the density of white bass and smallmouth bass in the discharge channel to some extent, as angler CUE's and station discharge flow were positively correlated. We observed indications that fish moved offshore during periods of strong onshore winds and that fish were more vulnerable to our nets when water transparency was poor.

While our data base on fish abundance, distribution, and composition is very large indeed, it is by no means complete. We failed to gain sufficient information about forage species and juveniles of most species. Only adults of a few species were caught frequently enough to develop reliable indices. Our larval fish catches consisted almost entirely of rainbow smelt, but we were unable to develop indices for juvenile and adult stages of this important commercial species because these age groups were not susceptible to our nets. Attempts to index the abundance of juvenile fishes in the Nanticoke area were unsuccessful because a predominance of rocky bottom precluded effective sampling with a bottom trawl. We were unable to make a detailed assessment of year-class strengths and recruitment for most species and for the major species in some years because of insufficient age composition data.

Our understanding of spatial variability in fish catches could have been improved had we a more complete description of habitat conditions, and how they may have influenced fish distribution and gear efficiency. We have almost no information concerning the winter distribution of fishes in the Nanticoke area, and it is still unclear how various species and age groups of fishes segregate in the thermal plume and behave relative to environmental stimuli.

With one exception, we have found no indication that the observed large annual, seasonal, and spatial variations in fish abundance, distribution and composition at Nanticoke were due to industrial development. Rather, such fluctuations are typical of temperate lakes exhibiting ever-changing environmental conditions, which in turn influence reproductive success, year-class strengths, recruitment, and distribution patterns of fish populations.

One of the most potentially harmful effects to fish at Nanticoke could have been the disruption of important spawning migrations by Stelco's dock or thermal/chemical industrial discharges, but this was not the case. The attraction of fish to the thermal plume has had an important beneficial impact from a socio-economic perspective. The development of a successful sport fishery at the heated outfall has provided local anglers many hours of recreation and area suppliers (fuel, bait, tackle) and services (marinas, commercial fish processors) financial benefits. It is interesting to note that some plume anglers have sold white bass to commercial fish processors, or have hired processors to clean their fish. From a biological perspective, continued accelerated exploitation of smallmouth bass by anglers, while of concern to fisheries managers, may be offset somewhat by increased recruitment.

Industrial development at Nanticoke was never static throughout the 13 years of our field studies and, even as monitoring ended in 1983, some important changes in industrial activities were occurring. The most notable changes were (a) the elimination of tempering condensor cooling water from Hydro's discharge (1983), and (b) increased discharges of chemicals arising from the recent commissionings of Stelco's coke ovens (1981) and hot strip mill (1983). Further study is required before we would care to speculate on the potential effects that these new developments might have on fish populations in the Nanticoke area.

# 4.0 FISH BIOLOGY

## 4.1 FOOD AND FEEDING

### Introduction

Stomach contents of selected fish species were monitored at Nanticoke to detect possible changes in diet as industrialization progressed. The long-term study (1971 - 1983) was intended principally to examine potential effects of the NTGS on adult fish diet. It was thought that such factors as elevated water temperatures and the strong current produced by the discharge waters could lead to changes in species composition and abundance of food organisms available to fish inhabiting the area. Other more short-term studies have been carried out to examine the diets of larval fish at Nanticoke (Munroe and Standke 1980) and the diets of adult fish in response to construction of the Stelco Dock (Chamberlain 1979).

The pre-operational (1971-1978) results of the long-term study have been reported by Kelso (1972, 1973a), Teleki (1973, 1976), Teleki *et al.* (1977) and Grant and Malhiot (1981). This program was discontinued in 1979 and 1980, and then re-established from 1981 through 1983. For the most part, this report discusses only the findings of the long-term study.

### Methods

#### A. Data Collection and Laboratory Procedures

The methods used in examining stomach contents have been similar since 1973 and are adequately documented by Grant and Malhiot (1981) for the

1971 - 1978 period, and by Pynenburg (1985) for the 1981-1983 period. Adult fish of four species (yellow perch, white bass, rock bass and smallmouth bass) were collected for stomach content analysis from the gillnet sets at the 'plume' and ' control' sites described in Section 3.2.2. Yellow perch was the principal species examined in the long-term study, whereas the remaining three species were examined less regularly and with less intensity. Within 2 - 3 hours of lifting the nets, fish were returned to the laboratory where (after 1974) the catch was grouped into 50-mm fork length classes beginning at 91-mm. Because insufficient numbers of larger fish were captured, all fish greater than 240 mm were grouped into a single length category (> 240 mm). Stomachs were excised at the laboratory from a maximum of 40 fish within each length class on a given sampling day and preserved in 5 - 10% formalin for later analysis. Fork lengths (mm) were recorded for each specimen in all years, and from 1981 - 1983, weight (g), sex, maturity and scale age were determined also.

Animal organisms in fish stomachs were identified to family or genus and counted, but for analytical convenience taxa were grouped into the 16 general food categories listed in Table 4.1-1. Non-digestible material was categorized as 'debris' while unidentifiable digestible material was categorized as 'other'. From 1973 - 1983 the volume of each taxon was determined by water displacement in graduated tubes. Volumes less than 0.05 ml were categorized as 'trace' amount (T). In 1971 and 1972 stomach contents were oven-dried at 105°C and weighed; because of the different methods used in these years, we do not consider these data in this report.

Larval fish samples for stomach analyses were collected from catches of our routine larval fish tows (Section 3.2.1). The digestive tracts of 2,048 rainbow smelt, 508 yellow perch and 389 alewife collected between 1971 and 1978 were examined by the OMNR Reaserch Station in Maple, Ontario; the methods and results are described by Munroe and Standke, (1980). Food studies of larval fish were discontinued after 1978 when the Research Section committment to zooplankton studies at Nanticoke ended.

B. Data Analyses

Stomach contents of all fish species examined were tabulated by the following four measurements as defined by Wallace (1981) for those fish species containing more than trace amounts as the total stomach volume:

Frequency of occurrence (F): the percentage of all stomachs (containing food) in which each food category occurred,

Percentage of the total number (N): the percentage that each food category contributed to the total number of food items in all stomachs,

Percentage of the total volume (V): the percentage that each food category contributed to the total volume of food in all stomachs, and

Average of the volume percentages ($\overline{V}$): the average percentage that each food category contributed to the total volume of food in each stomach.

Examinations of diet overlap and niche breadth across locations or species were estimated from using the following formulae:

Schoener Index $\alpha = 1 - 0.5 \left( \sum_{i=1}^{n} |p_{xi} - p_{yi}| \right)$

Levins Index $\alpha_{xy} = \sum_{i=1}^{n} (p_{xi} - p_{yi}) / \sum_{i=1}^{n} p_{yi}^2$

Niche Breadth $B = 1/\Sigma p_i^2$

Where: n = number of food categories

$p_{xi}$ = proportion of food category i in the diet of species x, and

$p_{yi}$ = proportion of food category i in the diet of species y

Average of the volume percentages ($\overline{v}$) was used in the above formulae as it is considered to be the 'least objectionable' measure of diet for calculations of overlap (Wallace 1981).

Sufficient sample sizes for statistical analyses were available only for yellow perch. Because of the large percentage of 0 scores for any given food category, standard parametric statistics (such as ANOVA) were judged inappropriate due to non-normal distributions and unequal variances. Instead, a categorical data analysis (Logit Analysis) was applied (see Section 3.1). Stomach contents of seven selected food categories (amphipods, midges, isopods, crayfish, caddisflies, fish and fish eggs) were divided into two categories: present (volume > 0) or absent (volume = 0), and data were grouped into the following three seasons and two periods for some analyses:

Season: spring (April 1 to June 30)
summer (July 1 to August 30)
fall (September 1 to November 30)

Period: preoperational (1971 - 1978)
operational (1979 - 1983)

The effects of year, season and location were examined using various combinations of the design factors to achieve the desired statistical model and avoid empty cells (no data collected in a particular year, season or location). Response frequencies (% with volume > 0) from the logit analyses were plotted to graphically depict trends.

Because the size of fish can influence the type of food consumed (Keast 1977, Keast and Webb 1966), a preliminary examination of this effect was carried out by applying logit analysis across the following fork length classes of yellow perch for each of the seven food categories:

91 - 140 mm
141 - 190 mm
191 - 240 mm
> 240 mm

As this effect was found to be highly significant (P = 0.0001) for most food categories, certain main effects were examined by first partitioning the data among the individual length classes or, because of insufficient cell sizes within most length classes, by using only the 141 - 190 mm length class which was, by far, the dominant length class in the samples.

Because of small sample sizes and a paucity of data for some years, food habits of smallmouth bass, white bass and rock bass were examined only by visual inspection of the data pooled across years and locations.

## Results

### Yellow Perch

### A. Diet Composition

Of the 14 identifiable food categories found in yellow perch stomachs over the study period, seven were found in every year (snails, isopods, amphipods, crayfish, midges and fish) (Tables 4.1-2 and -3). Amphipods were consistently the most important food of yellow perch at both locations regardless of the measurement considered. Other important food categories included crayfish, isopods, midges, caddisflies and fish.

## B. Body Size

While the general composition of yellow perch diet was similar among length classes, the relative importance of certain food categories changed with length. Fork length class produced a highly significant (P = 0.0001) effect in logit analysis on the occurrence of all food categories examined except fish eggs (Figures 4.1-1 and -2). In general, amphipods, isopods and midges declined in importance as length class increased, whereas fish increased in importance with length class (Figures 4.1-1 and -2). Crayfish increased in importance with length class, but then declined again in the >240 mm length class. Caddisflies occurred most frequently in the 141 - 190 mm length class (Figure 4.1-1).

## C. Season

The effect of season on occurrence of the seven food categories in the diet of yellow perch was statistically significant, regardless of length class (Table 4.1-4, Figure 4.1-5) and the seasonal trends are depicted graphically in Figures 4.1-3 to -5. While amphipods and midges were consumed heavily in all seasons, they tended to decline in importance as the seasons progressed (spring through fall). Crayfish and fish occurred in perch stomachs most frequently in the fall, while caddisflies occurred most frequently in summer. Fish eggs were consumed most frequently in spring and none were eaten in the fall. Isopods were consumed most frequently in spring and summer. These trends were consistent at both locations, and in both the preoperational and operational periods (Figure 4.1-6).

### D. Location

When all length classes and years were pooled in the logit analysis, significant differences in the occurrence of amphipods, midges, crayfish, isopods and fish eggs were detected across locations and, with the exception of crayfish, all categories were consumed more frequently at the plume location (Table 4.1-5). On the other hand, crayfish occurred significantly more frequently in perch diet at the control location. Similar results were obtained when only yellow perch from the 141 - 190 mm length class were used in logit analysis except that plume-control differences in the occurrence of amphipods, were no longer significant (Table 4.1-5).

Despite the above noted differences, the diets of yellow perch at the plume and control sites overlapped considerably in all seasons and in both periods (Table 4.1-6). The dominant food categories were similar at both locations (Table 4.1-3), and there was no strong seasonal trend in dietary overlap between the two locations although niche breadth generally was much wider in the summer at both locations.

### E. Year

Because the length class composition of yellow perch samples varied across years, interpretation of yearly trends could have been misleading if samples from all length classes were pooled. Consequently, these trends were examined also by considering samples solely from the 141 - 190 mm length class.

Significant differences in the occurrence of all seven food categories in perch diet were detected across years when locations were pooled (Tables 4.1-5 and -7), but when data from each location were treated independently differences in crayfish consumption across years were significant only at the control location, while significant differences in isopod and fish egg consumption across years occurred only at the plume location (Table 4.1-7). The occurrence of crayfish in yellow perch diet has tended to increase at the control location since 1978, and the significant difference across years in fish egg occurrence detected at the plume location was due principally to the large quantities consumed in 1978 (Figure 4.1-7). Isopod consumption declined at both locations after 1976, but subsequently has increased steadily at the plume location to reach pre- 1977 levels (Figure 4.1-8).

Upward and downward fluctuations in the consumption of caddisflies, amphipods and midges generally occurred in parallel at both locations over the study years, but the magnitude of plume-control differences in amphipod, crayfish and particularly midge occurrence has increased since 1978 (Figure 4.1-7). Indeed, whereas the effect of location on amphipod, isopod and midge consumption was not significant in the earlier years (1974 - 1978), this effect was highly significant in recent years (1981 - 1983) (Table 4.1-8, Figure 4.1-8).

### *Other Species*

Because of small sample sizes, detailed analyses of smallmouth bass, rock bass and white bass diets were not possible. However, certain general dietary tendencies were apparent from inspection of the tabulated results.

The dominant food of white bass at both locations was fish, although amphipods and midges were consumed also (Table 4.1-9). Large white bass preyed mostly on fish whereas small (< 91 mm) white bass consumed greater proportions of amphipods and midges (Pynenburg 1985).

Smallmouth bass of all sizes consumed principally crayfish and/or fish, although caddisflies, midges and amphipods alsc were consumed on occasion (Table 4.1-9). The diet of rock bass (principally crayfish and fish) appears quite similar to that of smallmouth bass, but sample sizes were very small in all years (Table 4.1-9).

## Discussion

### A. General Feeding Tendencies

Our limited observations of white bass, smallmouth bass and rock bass diet suggest that their broad dietary tendencies at Nanticoke conform closely to observations for these species in other water bodies. The diet of adult white bass at Nanticoke consisted almost entirely of fish, a tendency that has been well documented elsewhere (Forney and Taylor 1963, Priegel 1970, Olmstead and Kilambi 1971, Scott and Crossman 1973). Similarly, the diets of adult smallmouth bass and rock bass at Nanticoke (principally crayfish and fish) are typical of their feeding habits in other waters (Tester 1932, Keast and Webb 1966, Applegate et al. 1967, Keast and Welsh 1968, Scott and Crossman 1973, Hubert 1977). The diets of these three species overlapped considerably but, similar to the findings of Serns and Hoff (1984), dietary overlap between yellow perch and these species was limited (Table 4.1-10).

Yellow perch food habits at Nanticoke also have been very similar to dietary tendencies of the species in many other water bodies. Yellow perch typically are described as opportunistic feeders (Ney 1978) consuming a diverse assemblage of organisms; the species is adapted to a diet of small live animals, feeds mostly on bottom-dwelling organisms and will take whatever small animals are most available (Costa 1979, Herman *et al.* 1964, Thorpe 1977a). In comparison with the other species examined at Nanticoke, a wider variety of organisms usually were consumed by adult yellow perch (Tables 4.1-2, -3, and -9) and niche breadth was much wider for yellow perch (Table 4.1-10), although it tended to decrease for fish larger than 190-mm.

| Length Class | Niche Breadth |
|---|---|
| 90 - 140 | 2.722 |
| 141 - 190 | 5.664 |
| 191 - 240 | 4.887 |
| > 240 | 2.125 |

Similarly, of 3 species of larval fish examined (yellow perch, rainbow smelt and alewife), perch appeared to be the most opportunistic; perch diet became quite diverse by July, whereas nauplii, cyclopoids and *Diaptomus* remained the only major food of rainbow smelt and alewife (Grant and Malhiot 1981).

Yellow perch typically pass through three major dietary shifts as they grow to adult size. As body size increases, diet progressively shifts from predominately small crustaceans (eg. Cladocera) in larval and young-of-the-year perch, to a diversified range of benthos (mostly insect larvae) and, finally, to decopods (crayfish) and fish (Keast 1977, Clady 1974, Tharratt 1959). A similar tendency in the diet of Eurasian perch was described by McCormack (1970). Again, this broad trend in yellow perch dietary tendencies was clearly evident at Nanticoke where zooplankton were the major component of larval perch diet (Munroe and Standke 1980); thereafter, the diet shifted to benthos and finally to fish and crayfish as body size increased (Figures 4.1-1, and -2). Even within the larval stage, the dependency of diet on body size was apparent. Initially, yellow perch larvae selected small zooplankton nauplii over larger, more abundant cyclopoids whereas late in the season they selected intermediate sized zooplankton while ignoring the smaller forms, and yet still avoiding larger types such as Daphnia (Munroe and Standke 1980, Grant and Malhiot 1981).

As yellow perch are opportunistic feeders and diet seems to depend primarily on the availability of food organisms, seasonal changes in diet composition reflect seasonal changes in availability of the food categories (Costa 1979, Thorpe 1977b), although (as noted above) selection for size and quality of food also occur (Ney 1978). While complete analyses of NEC benthic macroinvertebrate studies at Nanticoke were not available at the time of writing, the available data suggest that seasonal changes in perch diet at Nanticoke do (as the generalization suggests) reflect seasonal changes in abundance of the food categories. Amphipods were consumed heavily in every month at Nanticoke, but their relative importance in perch diet declined strongly with season; similarly, amphipod abundance at Nanticoke declined steadily from May - November (Weiler and MacGregor 1985).

Caddisflies normally were consumed most frequently in summer and least frequently in spring; this corresponds generally to the observed rise and fall of caddisfly abundance through the seasons at Nanticoke (Weiler and MacGregor op. cit.). Midge larvae declined in importance in yellow perch diet with season as did the abundance of midge larvae in the benthic studies.

In summary, the broad dietary tendencies of yellow perch at Nanticoke correspond to those in other water bodies where similar studies have been carried out. The opportunistic nature of yellow perch feeding habits suggests that the species is well adapted to shifts in food availability; the most critical stage would seem to be the larval stage when zooplankton comprises the bulk of the diet.

## B. Trends In Yellow Perch Diet Through Years and Across Locations

The composition of yellow perch diet at the plume and control locations were similar within all length classes examined, and the diets of perch at both locations overlapped considerably in all seasons. Nevertheless, several differences in the relative importance of some food categories were noted between locations. Crayfish occurred more frequently in perch diet at the control location, whereas fish eggs occurred more frequently at the plume (particularly in recent years). Isopods declined in importance in perch diet after 1976, but subsequently the frequency of this food category in perch diet has increased steadily at the plume, beginning in 1981. Recently, the frequency of isopods, midges and amphipods in perch diet has increased at the plume location, relative to the control location.

Higher frequencies of fish eggs in yellow perch diet at the plume than at the control location is almost certainly due to fish spawning in the NTGS discharge channel, (see section 4.2) and the higher frequencies of crayfish in perch diet at the control site are likely due to the presence of substrate conditions more suitable to these organisms (rock and cobble were observed at the control site, whereas the plume site was comprised almost totally of silt and mud; see section 3.2.2).

The broad taxonomic composition of yellow perch diet has remained similar from year to year; amphipods (mostly Gammarus) have always been the dominant food cateogory in the diet, which is not unusual as the importance of amphipods in the diet of both yellow and Eurasian perch has been noted in several other studies (Tharatt 1959, Elrod et al. 1981, McCormack 1970, Serns and Hoff 1984). However, the relative importance of some food categories has changed, apparently reflecting a real change in diet. The importance of amphipods and midges in perch diet generally has increased since 1976, particularly at the plume location where their dominance as a food item has remained more consistent. Crayfish appeared to occur in perch stomachs more frequently in recent years at the control location, whereas the importance of caddisflies in perch diet has declined at the same site.

The occurrence of mayflies in yellow perch stomachs could not be examined statistically; however, the importance of this environmentally sensitive organism in perch diet appears to have decreased since 1974 (Tables 4.1-2, and -3). Grant and Malhiot (1981) pooled data from both locations and all length classes, and included the pre-1974 data in his analyses; in so doing they found that both caddisflies and mayflies declined in importance in perch diet from 1974 - 1978 at Nanticoke, (these trends apparently were statistically significant). However, the comparability of pre-1973 data is suspect (see Methods). Moreover, as trends at the two locations have been dissimilar, and the length class composition of the samples have been inconsistent from year to year, these results are questionable.

As discussed previously, the opportunistic feeding habits of yellow perch suggests that the relative importance of a given food category in perch diet likely reflects abundance of that category in the environment. The observed changes in relative importance of certain food categories (eg. midges and amphipods) at the plume, therefore, may represent true changes in the general abundances of these organisms. While this must be tested by examining the results of NEC benthic macroinvertebrate studies, such changes are not unexpected. Storr and Schlenker (1974) observed strong increases in gammarid abundance near the heated water discharge of the Nine Mile Point Nuclear facility on Lake Ontario. These authors suggest that the increased abundance was caused largely by an increase in shore temperatures bounding the discharge area. The effect of temperature could be direct in that incubation periods and molting time are reduced when temperatures are elevated. Alternatively, increased temperature could lead indirectly to increases in gammarid abundance by accelerating growth of attached algae (the relationship of attached algae growth to temperature has been described by Bellis 1968; Storr and Sweeney 1971; Wong _et_ _al_. 1978; and Neil and Jackson 1982). As amphipods (_Gammarus_ sp.) often are the dominant organism found in algae, increases in amphipod abundance could be due to increases in attached algae biomass near the heated water discharge area. Similar explanations for changes in the other food categories may exist, and changes in substrate at the discharge channel (eg. through sedimentation) could be a strong causal factor; however, such interpretations must await results from the benthic studies at Nanticoke.

Table 4.1-1. Description of food categories used in stomach contents analyses.

| FOOD CATEGORY | DESCRIPTION |
|---|---|
| Worms | includes sludge worms, Oligochaeta and leeches (Hirudinea) |
| Snails | taxa unknown |
| Water fleas | taxa unknown |
| Isopods | principally *Asellus* |
| Amphipods | principally *Gammarus* |
| Crayfish | includes *Orconectes* and *Cambarus* |
| Mayflies | includes *Stenonema* |
| Caddisflies | includes *Leptoceridae* |
| Midges | principally Chironomidae |
| Fish adults | includes rainbow smelt, shiners (Notropis spp.) and yellow perch |
| Fish eggs | principally rainbow smelt eggs |
| Larval fish | principally rainbow smelt |
| Clams | taxa unknown |
| Other | unidentifiable digestible material |
| Debris | undigestible material |

Table 4.1-2. Stomach contents of yellow perch taken at Nanticoke, Long Point Bay, Lake Erie (1973-1983). Contents are expressed as frequency of occurrence (F), percentage of total number (N) and percentage of total volume (V). t = trace amount.

| PLUME | 1973 | | | 1974 | | | 1975 | | | 1976 | | | 1977 | | | 1978 | | | 1981 | | | 1982 | | | 1983 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | %F | %N | %V | %F | %N | %V | %F | %N | %V | %F | %N | %V | %F | %N | %V | %F | %N | %V | %F | %N | %V | %F | %N | %V | %F | %N | %V |
| Worms | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 12.1 | 0.1 | 3.0 | 2.4 | 0.1 | 0.7 | 9.6 | 1.0 | 2.9 | 4.5 | 0.3 | 0.4 |
| Snails | | | | 10.7 | 0.5 | 0.2 | 8.7 | 0.9 | 0.7 | 9.1 | 0.2 | 1.3 | 10.1 | 0.4 | 0.7 | 2.7 | 0.1 | 0.5 | 6.2 | 0.7 | 1.3 | 6.2 | 1.5 | 4.1 | 5.2 | 0.6 | 1.6 |
| Water Fleas | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.5 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 27.5 | 1.0 | 0.0 | 0.0 | 0.0 |
| Isopoda | | | | 17.9 | 1.9 | 0.3 | 15.2 | 1.1 | 1.5 | 27.3 | 0.9 | 0.5 | 8.1 | 1.0 | 0.6 | 2.7 | T | 0.1 | 5.9 | 0.4 | 0.8 | 8.7 | 0.7 | 0.6 | 22.0 | 3.3 | 2.3 |
| Amphipoda | | | | 42.9 | 83.0 | 15.7 | 47.8 | 61.2 | 20.8 | 72.7 | 82.1 | 49.2 | 64.6 | 46.1 | 38.1 | 65.1 | 1.0 | 14.2 | 50.9 | 27.9 | 34.5 | 50.3 | 15.8 | 22.1 | 78.0 | 62.1 | 69.7 |
| Crayfish | | | | 10.7 | 0.8 | 3.3 | 6.5 | 3.5 | 8.8 | 0.0 | 0.0 | 0.0 | 8.1 | 0.3 | 7.1 | 3.4 | T | 1.6 | 4.1 | 0.3 | 6.7 | 4.1 | 0.1 | 4.3 | 5.8 | 0.3 | 5.8 |
| Mayflies | | | | 7.1 | 0.6 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 0.1 | T | 7.4 | T | 0.9 | 0.3 | T | T | 1.6 | T | 0.3 | 0.6 | T | T |
| Caddisflies | | | | 3.6 | 1.9 | 3.3 | 17.4 | 4.7 | 3.1 | 0.0 | 0.0 | 0.0 | 6.1 | 7.5 | 3.1 | 10.7 | 0.2 | 2.4 | 7.6 | 0.7 | 1.7 | 19.7 | 4.4 | 9.6 | 9.3 | 1.1 | 1.2 |
| Midges | | | | 17.9 | 7.5 | 0.8 | 26.1 | 30.8 | 7.4 | 54.5 | 14.0 | 3.7 | 50.5 | 43.2 | 17.5 | 77.9 | 2.5 | 17.3 | 55.9 | 59.3 | 29.1 | 46.5 | 16.6 | 11.5 | 55.5 | 23.5 | 12.1 |
| Other Arthropoda | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 9.1 | 0.2 | 2.0 | 3.0 | 0.1 | 0.6 | 2.7 | T | 0.1 | 4.1 | 0.4 | 0.3 | 2.3 | 0.1 | 0.2 | 1.7 | 0.1 | 0.1 |
| Fish Adults | | | | 42.9 | 1.7 | 77.7 | 10.9 | 0.9 | 43.8 | 13.6 | 1.9 | 18.1 | 13.1 | 0.5 | 27.6 | 2.7 | T | 1.7 | 2.4 | 0.1 | 4.3 | 6.9 | 0.2 | 26.7 | 2.4 | 0.1 | 4.1 |
| Fish Eggs | | | | 0.0 | 0.0 | 0.0 | 8.7 | 0.0 | 11.9 | 4.5 | 0.6 | 0.5 | 0.0 | 0.0 | 0.0 | 47.0 | 96.1 | 53.1 | 5.9 | 10.1 | 4.0 | 4.1 | 32.1 | 3.8 | 3.0 | 8.4 | 0.7 |
| Larval Fish | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.0 | 0.1 | 2.2 | 0.0 | 0.0 | 0.0 | 0.3 | T | 0.1 | 0.7 | 0.0 | 0.8 | 3.2 | 0.2 | 0.2 |
| Clams | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.1 | 0.1 | 0.1 | 1.6 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 |
| Other (Digestible) | | | | 3.6 | 0.0 | 0.1 | 6.5 | 0.0 | 0.9 | 22.7 | 0.0 | 24.6 | 14.1 | 0.0 | 2.0 | 42.3 | 0.0 | 5.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.1 | 0.7 | 0.0 | T |
| Debris (Undigestible) | | | | 3.6 | 0.0 | 0.5 | 4.3 | 0.0 | 1.3 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.2 | 1.1 | 0.0 | 0.1 | 39.4 | 0.0 | 16.4 | 40.3 | 0.0 | 11.8 | 10.2 | 0.0 | 1.8 |
| Total Volume | | | | | 39.77 | | | 32.82 | | | 19.19 | | | 46.81 | | | 77.90 | | | 113.95 | | | 182.85 | | | 205.93 | |
| No. of Stomachs | | | | | 43 | | | 56 | | | 27 | | | 137 | | | 177 | | | 485 | | | 606 | | | 674 | |
| No. Not Empty | | | | | 28 | | | 46 | | | 22 | | | 99 | | | 149 | | | 340 | | | 437 | | | 537 | |
| % Containing Food | | | | | 65.1 | | | 82.1 | | | 81.5 | | | 72.3 | | | 84.2 | | | 70.1 | | | 72.1 | | | 79.7 | |
| CONTROL | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Worms | 0.0 | 0.0 | 0.0 | 5.3 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.8 | 0.2 | 0.2 | 2.6 | 2.1 | 0.6 | 0.8 | T | 0.1 | 2.7 | 0.4 | 0.4 | 1.2 | 0.4 | 0.2 |
| Snails | 10.4 | 1.7 | 8.9 | 5.3 | 0.2 | 0.1 | 13.3 | 0.6 | 0.9 | 4.3 | 0.1 | 0.3 | 6.3 | 0.1 | 0.2 | 5.1 | 0.5 | 0.3 | 6.2 | 1.0 | 1.4 | 6.2 | 0.8 | 1.3 | 4.6 | 1.1 | 1.3 |
| Water Fleas | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.9 | 60.0 | 2.2 | 0.3 | 0.0 | T |
| Isopoda | 4.2 | 1.2 | 0.5 | 10.5 | 1.1 | 0.6 | 10.0 | 10.6 | 1.1 | 34.8 | 4.1 | 1.0 | 3.1 | T | 0.1 | 5.1 | 0.3 | 0.1 | 6.2 | 0.8 | 0.8 | 3.9 | 0.9 | 0.4 | 7.4 | 1.2 | 1.1 |
| Amphipoda | 52.1 | 75.8 | 20.4 | 57.9 | 75.0 | 32.0 | 40.0 | 25.9 | 5.6 | 65.2 | 44.2 | 42.0 | 64.1 | [illegible] | 14.7 | 51.3 | 40.3 | 26.6 | 38.0 | 38.6 | 27.7 | 30.9 | 19.8 | 16.1 | 66.5 | 66.3 | 44.7 |
| Crayfish | 33.3 | 1.7 | 23.0 | 10.5 | 0.5 | 3.6 | 10.0 | 0.6 | 4.3 | 4.3 | 0.3 | 3.1 | 21.9 | 0.2 | 10.0 | 10.3 | 0.6 | 4.4 | 19.4 | 1.1 | 22.8 | 26.3 | 1.3 | 34.5 | 20.9 | 1.4 | 29.5 |
| Mayflies | 0.0 | 0.0 | 0.0 | 10.5 | 0.3 | 0.6 | 3.3 | 0.1 | 3.2 | 0.0 | 0.0 | 0.0 | 1.6 | T | T | 2.6 | 0.1 | 0.6 | 0.0 | 0.0 | 0.0 | 1.5 | 0.2 | 0.3 | 1.2 | 0.1 | 0.1 |
| Caddisflies | 22.9 | 11.1 | 9.0 | 21.1 | 18.8 | 10.8 | 40.0 | 53.2 | 6.0 | 8.7 | 0.3 | 3.0 | 12.5 | 0.9 | 1.2 | 2.6 | 1.0 | 1.6 | 7.8 | 2.7 | 4.5 | 16.2 | 5.2 | 6.3 | 8.0 | 1.5 | 1.8 |
| Midges | 14.6 | 1.6 | 0.9 | 31.6 | 2.9 | 1.4 | 13.3 | 6.5 | 1.6 | 52.2 | 10.3 | 4.2 | 89.1 | 81.6 | 56.7 | 51.3 | 51.9 | 12.6 | 31.8 | 55.1 | 16.1 | 17.4 | 7.5 | 2.7 | 37.8 | 23.5 | 7.4 |
| Other Arthropoda | 4.2 | 3.3 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8.7 | 0.1 | 0.8 | 7.8 | 0.1 | 0.7 | 7.7 | 0.4 | 0.6 | 7.0 | 0.4 | 0.4 | 0.4 | T | T | 1.8 | 0.1 | 0.8 |
| Fish Adults | 22.9 | 1.5 | 30.8 | 26.3 | 1.2 | 41.7 | 6.7 | 0.4 | 51.5 | 8.7 | 0.4 | 4.3 | 7.8 | 0.1 | 10.1 | 23.1 | 2.6 | 40.1 | 2.3 | 0.1 | 8.2 | 12.0 | 0.5 | 24.8 | 3.7 | 0.1 | 8.5 |
| Fish Eggs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.7 | 0.1 | 0.4 | 0.8 | 1.3 | 0.3 | 0.8 | 3.5 | T | 1.8 | 3.9 | 0.7 |
| Larval Fish | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | T | T | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.3 | 1.8 | 0.4 | 0.6 |
| Clams | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.1 | 0.9 | 1.8 | 1.2 | T | T | 0.0 | 0.0 | 0.0 |
| Other (Digestible) | 4.2 | 0.0 | 5.0 | 0.0 | 0.0 | 0.0 | 13.3 | 0.0 | 1.1 | 78.3 | 0.0 | 40.0 | 10.9 | 0.0 | 1.1 | 71.8 | 0.0 | 12.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.4 | 0.6 | 0.0 | 0.1 |
| Debris (Undigestible) | 2.1 | 0.0 | 0.5 | 10.5 | 0.0 | 8.4 | 13.3 | 0.0 | 24.7 | 0.0 | 0.0 | 0.0 | 1.6 | 0.0 | T | 0.0 | 0.0 | 0.0 | 41.1 | 0.0 | 15.9 | 31.7 | 0.0 | 10.3 | 9.2 | 0.0 | 1.4 |
| Total Volume | | 44.17 | | | 19.70 | | | 44.66 | | | 29.60 | | | 67.80 | | | 16.00 | | | 62.00 | | | 144.22 | | | 138.58 | |
| No. of Stomachs | | 72 | | | 27 | | | [illegible] | | | 25 | | | 91 | | | 51 | | | 209 | | | 374 | | | 439 | |
| No. Not Empty | | 48 | | | 19 | | | 30 | | | 23 | | | 64 | | | 39 | | | 129 | | | 259 | | | 325 | |
| % Containing Food | | 66.7 | | | 70.4 | | | [illegible] | | | 92.0 | | | 70.3 | | | 76.5 | | | 61.7 | | | 69.3 | | | 74.0 | |

[illegible]

[illegible]

Table 4.1-3. Stomach contents of yellow perch taken at Nanticoke, Long Point Bay, Lake Erie (1973-1983). Contents are expressed as average of the volume percentages ($\bar{v}$).

| [illegible] | 1974 | | | | [illegible] | | | | [illegible] | | | | [illegible] | | | | [illegible] | | | | 1981 | | | | 1982 | | | | 1983 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Spring | Summer | Fall | Combined | Spring | Summer | Fall | Combined | Spring | Summer | Fall | Combined | Spring | Summer | Fall | Combined | Spring | Summer | Fall | Combined | Spring | Summer | Fall | Combined | Spring | Summer | Fall | Combined | Spring | Summer | Fall | Combined |
| [illegible] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Worms | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 1.08 | 2.67 | 0.10 | 0.00 | 0.85 | 1.97 | 4.42 | 0.42 | 2.49 | 0.05 | 0.59 | 2.53 | 0.60 |
| Snails | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 1.35 | 0.06 | 1.44 | 1.11 | 1.03 | 1.00 | 4.78 | 6.38 | 3.69 | 0.00 | 2.00 | 5.84 | 1.58 |
| Water fleas | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0.09 | 0.00 | 3.00 | 1.00 | 0.00 | 0.00 | 4.07 | 0.00 | 1.71 | 0.00 | 0.00 | 0.00 | 0.00 |
| Isopods | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0.28 | 1.07 | 0.26 | 0.00 | 0.40 | 0.36 | 1.06 | 1.53 | 0.89 | 0.58 | 6.34 | 6.16 | 3.60 |
| Amphipods | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 17.50 | 56.71 | 15.46 | 36.11 | 27.83 | 44.71 | 10.27 | 24.09 | 25.87 | 76.47 | 70.61 | 28.30 | 69.16 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 2.42 | 1.18 | 2.12 | 25.40 | 4.03 | 0.23 | 2.42 | 25.06 | 6.22 | 0.04 | 3.04 | 13.96 | 5.85 |
| Mayflies | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 1.25 | 0.24 | 0.00 | 0.00 | 0.07 | 0.73 | 1.01 | 0.00 | 0.70 | 0.00 | 0.18 | 0.00 | 0.07 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 1.13 | 0.49 | 1.45 | 0.00 | 2.35 | 2.02 | 23.01 | 2.10 | 10.96 | 0.41 | 2.30 | 5.00 | 1.79 |
| Midges | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 21.50 | 21.50 | 26.77 | 0.74 | 22.78 | 17.06 | 16.21 | 16.17 | 16.52 | 21.69 | 9.46 | 7.42 | 16.95 |
| Other Arthropods | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0.18 | 0.44 | 0.29 | 0.00 | 0.45 | 0.24 | 0.12 | 1.11 | 0.45 | 0.00 | 0.14 | 0.00 | 0.10 |
| Fish Adults | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 1.42 | 4.47 | 0.71 | 1.90 | 3.12 | 11.37 | 4.72 | 14.26 | 9.14 | 1.65 | 1.52 | 2.63 | 1.76 |
| Fish Eggs | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 40.15 | 12.46 | 0.00 | 0.00 | 3.70 | 10.15 | 0.02 | 0.00 | 1.78 | 2.37 | 0.26 | 0.00 | 1.22 |
| Parts of Fish | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0.00 | 0.00 | 3.57 | 0.00 | 0.15 | 1.93 | 0.00 | 3.00 | 0.72 | 0.00 | 0.00 | 0.00 | 0.00 |
| Clams | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0.00 | 0.29 | 0.00 | 0.00 | 0.13 | 0.00 | 0.56 | 0.07 | 0.25 | 0.13 | 0.52 | 1.64 | 0.49 |
| [illegible] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Worms | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0.10 | 1.10 | 0.00 | 0.05 | 0.14 | 0.65 | 0.00 | 0.29 | 0.00 | 0.13 | 0.57 | 0.30 |
| Snails | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0.07 | 4.44 | 0.56 | 2.50 | 3.98 | 2.75 | 2.00 | 2.81 | 0.06 | 7.67 | 1.56 | 2.23 |
| Water fleas | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0.10 | 3.00 | 0.00 | 0.00 | 0.00 | 18.67 | 0.00 | 4.12 | 0.00 | 0.00 | 0.01 | 0.01 |
| Isopods | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0.04 | 0.13 | 0.00 | 1.29 | 0.20 | 0.22 | 0.14 | 0.18 | 2.01 | 1.03 | 0.06 | 1.05 |
| Amphipods | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 67.48 | 12.70 | 12.74 | 22.19 | 36.88 | 5.12 | 14.27 | 17.80 | 66.00 | 15.89 | 47.21 | 52.28 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 6.50 | 1.07 | 50.00 | 10.41 | 9.67 | 22.14 | 64.89 | 12.66 | 1.90 | 11.85 | 15.35 | 22.05 |
| Mayflies | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0.00 | 0.00 | 1.00 | 0.00 | 1.57 | 0.60 | 0.00 | 0.44 | 0.23 | 0.00 | 0.22 | 0.10 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0.14 | 4.65 | 0.00 | 2.44 | 1.78 | 10.16 | 9.00 | 7.50 | 0.20 | 1.27 | 7.57 | 1.27 |
| Midges | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 12.54 | 19.06 | 0.19 | 12.14 | 3.53 | 6.77 | 0.10 | 3.65 | 21.56 | 0.28 | 0.99 | 11.56 |
| Other Arthropods | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 1.84 | 9.18 | 0.00 | 0.39 | 0.36 | 0.00 | 0.00 | 0.10 | 0.03 | 0.40 | 1.04 | 0.50 |
| Fish Adults | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 1.06 | 3.30 | 5.56 | 1.88 | 27.01 | 0.14 | 10.21 | 14.10 | 4.26 | 2.97 | 2.13 | 3.24 |
| Fish Eggs | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0.21 | 0.00 | 0.00 | 0.04 | 0.00 | 0.06 | 0.00 | 0.01 | 2.10 | 0.00 | 0.03 | 0.85 |
| Parts of Fish | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0.05 | 0.00 | 0.00 | 0.00 | 0.91 | 0.00 | 0.00 | 0.26 | 0.00 | 0.00 | 0.00 | 0.00 |
| Clams | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0.00 | 0.06 | 1.74 | 1.78 | 0.00 | 0.25 | 0.00 | 0.10 | 0.00 | 2.00 | 0.12 | 0.49 |

Table 4.1-4. Effect of season among length classes on the consumption of selected food items by yellow perch at Nanticoke, Long Point Bay, Lake Erie (1974-1983; pooled locations, years).

| SOURCE OF VARIATION BY LENGTH CLASS | df | AMPHIPODS | | MIDGES | | CRAYFISH | |
|---|---|---|---|---|---|---|---|
| | | $\chi^2$ | P | $\chi^2$ | P | $\chi^2$ | P |
| 91-140 | | | | | | | |
| Intercept | 1 | 83.98 | 0.0001 | 0.10 | 0.7544 | 77.49 | 0.0001 |
| Season | 2 | 19.36 | 0.0001 | 56.44 | 0.0001 | 31.11 | 0.0001 |
| 141-190 | | | | | | | |
| Intercept | 1 | 18.30 | 0.0001 | 41.31 | 0.0001 | 372.09 | 0.0001 |
| Season | 2 | 114.81 | 0.0001 | 125.76 | 0.0001 | 144.31 | 0.0001 |
| 191-240 | | | | | | | |
| Intercept | 1 | 1.61 | 0.2045 | 12.34 | 0.0004 | 27.99 | 0.0001 |
| Season | 2 | 26.31 | 0.0001 | 12.26 | 0.0022 | 22.94 | 0.0001 |
| All Length Classes | | | | | | | |
| Intercept | 1 | 49.68 | 0.0001 | 49.45 | 0.0001 | 557.67 | 0.0001 |
| Season | 2 | 179.91 | 0.0001 | 226.26 | 0.0001 | 225.88 | 0.0001 |

| SOURCE OF VARIATION BY LENGTH CLASS | df | CADDISFLIES | | FISH | | FISH EGGS | |
|---|---|---|---|---|---|---|---|
| | | $\chi^2$ | P | $\chi^2$ | P | $\chi^2$ | P |
| 91-140 | | | | | | | |
| Intercept | 1 | 131.00 | 0.0001 | 88.69 | 0.0001 | 50.94 | 0.0001 |
| Season | 2 | 10.75 | 0.0046 | 17.05 | 0.0002 | 7.20 | 0.0273 |
| 141-190 | | | | | | | |
| Intercept | 1 | 371.22 | 0.0001 | 528.52 | 0.0001 | 111.78 | 0.0001 |
| Season | 2 | 86.89 | 0.0001 | 10.99 | 0.0041 | 65.36 | 0.0001 |
| 191-240 | | | | | | | |
| Intercept | 1 | 65.46 | 0.0001 | 36.49 | 0.0001 | 29.76 | 0.0001 |
| Season | 2 | 1.32 | 0.5180 | 18.37 | 0.0001 | 14.03 | 0.0009 |
| All Length Classes | | | | | | | |
| Intercept | 1 | 623.39 | 0.0001 | 768.96 | 0.0001 | 124.02 | 0.0001 |
| Season | 2 | 107.75 | 0.0001 | 55.89 | 0.0001 | 76.61 | 0.0001 |

Table 4.1-5. Effect of location and year on the consumption of selected food items by yellow perch at Nanticoke, Long Point Bay, Lake Erie (1974-1983; pooled seasons).

| SOURCE OF VARIATION BY LENGTH CLASS | df | AMPHIPODS | | MIDGES | | CRAYFISH | | CADDISFLIES | |
|---|---|---|---|---|---|---|---|---|---|
| | | $\chi^2$ | P | $\chi^2$ | P | $\chi^2$ | P | $\chi^2$ | P |
| 141-190 | | | | | | | | | |
| Intercept | 1 | 7.67 | 0.0056 | 4.09 | 0.0432 | 128.25 | 0.0001 | 105.89 | 0.0001 |
| Location | 1 | 1.70 | 0.1923 | 15.08 | 0.0001 | 8.16 | 0.0043 | 1.02 | 0.3130 |
| Year | 7 | 122.19 | 0.0001 | 22.12 | 0.0024 | 14.40 | 0.0443 | 44.27 | 0.0001 |
| Year x Location | 7 | 6.37 | 0.4978 | 15.24 | 0.0331 | 8.04 | 0.3291 | 7.91 | 0.3409 |
| All Length Classes | | | | | | | | | |
| Intercept | 1 | 15.37 | 0.0001 | 9.97 | 0.0016 | 211.51 | 0.0001 | 194.66 | 0.0001 |
| Location | 1 | 6.83 | 0.0090 | 10.28 | 0.0013 | 14.42 | 0.0001 | 2.62 | 0.1055 |
| Year | 7 | 194.01 | 0.0001 | 70.88 | 0.0001 | 11.72 | 0.1102 | 60.81 | 0.0001 |
| Year x Location | 7 | 10.46 | 0.1638 | 26.33 | 0.0004 | 9.75 | 0.2029 | 14.91 | 0.0372 |

| SOURCE OF VARIATION BY LENGTH CLASS | df | FISH | | FISH EGGS | | ISOPODS | |
|---|---|---|---|---|---|---|---|
| | | $\chi^2$ | P | $\chi^2$ | P | $\chi^2$ | P |
| 141-190 | | | | | | | |
| Intercept | 1 | 160.71 | 0.0001 | 138.46 | 0.0001 | 164.29 | 0.0001 |
| Location | 1 | 1.18 | 0.2771 | 4.81 | 0.0283 | 29.18 | 0.0001 |
| Year | 7 | 35.74 | 0.0001 | 29.93 | 0.0001 | 1.46 | 0.2266 |
| Year x Location | 7 | 12.88 | 0.0752 | 2.18 | 0.9495 | 10.11 | 1.0000 |
| All Length Classes | | | | | | | |
| Intercept | 1 | 348.07 | 0.0001 | 178.41 | 0.0001 | 312.73 | 0.0001 |
| Location | 1 | 0.40 | 0.5250 | 62.24 | 0.0001 | 46.32 | 0.0001 |
| Year | 7 | 70.81 | 0.0001 | 5.84 | 0.0157 | 2.37 | 0.1236 |
| Year x Location | 7 | 21.68 | 0.0029 | 6.78 | 0.4518 | 15.73 | 0.0277 |

Table 4.1-6. . Levins' (1968) Niche Breadth and Schoener (1970) overlap indices of yellow perch taken at Nanticoke, Long Point Bay, Lake Erie (preoperational and operational periods)[1] .

| | NICHE BREADTH | | SCHOENER INDEX | LEVINS INDEX | |
|---|---|---|---|---|---|
| SEASON | PLUME | CONTROL | PLUME VS CONTROL | PLUME ON CONTROL | CONTROL ON PLUME |
| | | | PREOPERATIONAL | | |
| Spring | 1.946 | 3.373 | 0.581 | 0.523 | 0.941 |
| Summer | 5.713 | 5.328 | 0.825 | 0.988 | 0.921 |
| Fall | 5.299 | 3.232 | 0.843 | 1.2533 | 0.765 |
| Combined | 5.145 | 5.323 | 0.749 | 0.854 | 0.883 |
| | | | OPERATIONAL | | |
| Spring | 3.105 | 2.599 | 0.811 | 1.058 | 0.885 |
| Summer | 13.780 | 8.025 | 0.728 | 0.995 | 0.580 |
| Fall | 2.988 | 6.030 | 0.716 | 0.659 | 1.329 |
| Combined | 5.575 | 5.752 | 0.775 | 0.842 | 0.869 |

[1] Average of the volume percentages ($\bar{v}$) were used in the above calculations.

Table 4.1-7. Effect of year on the consumption of selected food items by yellow perch at Nanticoke, Long Point Bay, Lake Erie (1974-1983; pooled season, length class = 141-190 mm).

| SOURCE OF VARIATION BY LOCATION | df | AMPHIPODS | | MIDGES | | CRAYFISH | | CADDISFLIES | |
|---|---|---|---|---|---|---|---|---|---|
| | | $X^2$ | P | $X^2$ | P | $X^2$ | P | $X^2$ | P |
| Plume | | | | | | | | | |
| Intercept | 1 | 12.83 | 0.0003 | 2.67 | 0.1025 | 103.84 | 0.0001 | 69.47 | 0.0001 |
| Year | 7 | 56.66 | 0.0001 | 35.79 | 0.0001 | 9.59 | 0.2130 | 31.86 | 0.0001 |
| Control | | | | | | | | | |
| Intercept | 1 | 0.79 | 0.3732 | 12.91 | 0.0003 | 34.76 | 0.0001 | 39.84 | 0.0001 |
| Year | 7 | 69.88 | 0.0001 | 19.07 | 0.0080 | 13.78 | 0.0553 | 25.92 | 0.0005 |
| Locations Combined | | | | | | | | | |
| Intercept | 1 | 15.45 | 0.0001 | 0.00 | 0.9472 | 111.95 | 0.0001 | 128.21 | 0.0001 |
| Year | 7 | 113.66 | 0.0001 | 52.99 | 0.0001 | 23.35 | 0.0015 | 51.16 | 0.0001 |

| SOURCE OF VARIATION BY LOCATION | df | FISH | | FISH EGGS | | ISOPODS | |
|---|---|---|---|---|---|---|---|
| | | $X^2$ | P | $X^2$ | P | $X^2$ | P |
| Plume | | | | | | | |
| Intercept | 1 | 113.23 | 0.0001 | 73.67 | 0.0001 | 196.13 | 0.0001 |
| Year | 7 | 24.42 | 0.0010 | 129.46 | 0.0001 | 49.59 | 0.0001 |
| Control | | | | | | | |
| Intercept | 1 | 57.73 | 0.0001 | 70.72 | 0.0001 | 72.06 | 0.0001 |
| Year | 7 | 26.41 | 0.0004 | 8.56 | 0.2859 | 13.22 | 0.0670 |
| Locations Combined | | | | | | | |
| Intercept | 1 | 145.66 | 0.0001 | 106.88 | 0.0001 | 170.07 | 0.0001 |
| Year | 7 | 38.81 | 0.0001 | 171.46 | 0.0001 | 46.63 | 0.0001 |

Table 4.1-8. Effect of year and location on the consumption of selected food categories by yellow perch at Nanticoke, Long Point Bay, Lake Erie within the 1974-1978 and 1981-1983 periods (length class = 141-190 mm).

| **SOURCE OF VARIATION BY PERIOD** | **df** | **AMPHIPODS** | | **MIDGES** | | **CRAYFISH** | |
|---|---|---|---|---|---|---|---|
| | | $X^2$ | P | $X^2$ | P | $X^2$ | P |
| 1974-1978 | | | | | | | |
| Intercept | 1 | 7.39 | 0.0066 | 0.29 | 0.5927 | 65.37 | 0.0001 |
| Year | 4 | 12.13 | 0.0164 | 12.70 | 0.0128 | 2.50 | 0.6445 |
| Location | 1 | 0.01 | 0.9048 | 3.37 | 0.0663 | 1.47 | 0.2249 |
| Year x Location | 4 | 0.62 | 0.9612 | 7.09 | 0.1312 | 2.18 | 0.7029 |
| 1981-1983 | | | | | | | |
| Intercept | 1 | 0.30 | 0.5869 | 40.01 | 0.0001 | 293.45 | 0.0001 |
| Year | 2 | 105.89 | 0.0001 | 3.03 | 0.2204 | 7.03 | 0.0297 |
| Location | 1 | 24.29 | 0.0001 | 78.18 | 0.0001 | 70.49 | 0.0001 |
| Year x Location | 2 | 1.69 | 0.4305 | 0.63 | 0.7313 | 2.41 | 0.2995 |

| **SOURCE OF VARIATION BY PERIOD** | **df** | **CADDISFLIES** | | **FISH** | | **FISH EGGS** | |
|---|---|---|---|---|---|---|---|
| | | $X^2$ | P | $X^2$ | P | $X^2$ | P |
| 1974-1978 | | | | | | | |
| Intercept | 1 | 46.41 | 0.0001 | 57.57 | 0.0001 | 52.33 | 0.0001 |
| Year | 4 | 16.26 | 0.0027 | 9.21 | 0.0561 | 18.31 | 0.0011 |
| Location | 1 | 1.39 | 0.2392 | 0.60 | 0.4376 | 0.96 | 0.3282 |
| Year x Location | 4 | 1.27 | 0.8661 | 11.31 | 0.0233 | 0.83 | 0.9341 |
| 1981-1983 | | | | | | | |
| Intercept | 1 | 308.15 | 0.0001 | 189.31 | 0.0001 | 139.53 | 0.0001 |
| Year | 2 | 27.70 | 0.0001 | 23.30 | 0.0001 | 0.59 | 0.7439 |
| Location | 1 | 0.48 | 0.4899 | 0.83 | 0.3635 | 8.64 | 0.0033 |
| Year x Location | 2 | 0.43 | 0.8066 | 0.68 | 0.7130 | 0.86 | 0.6517 |

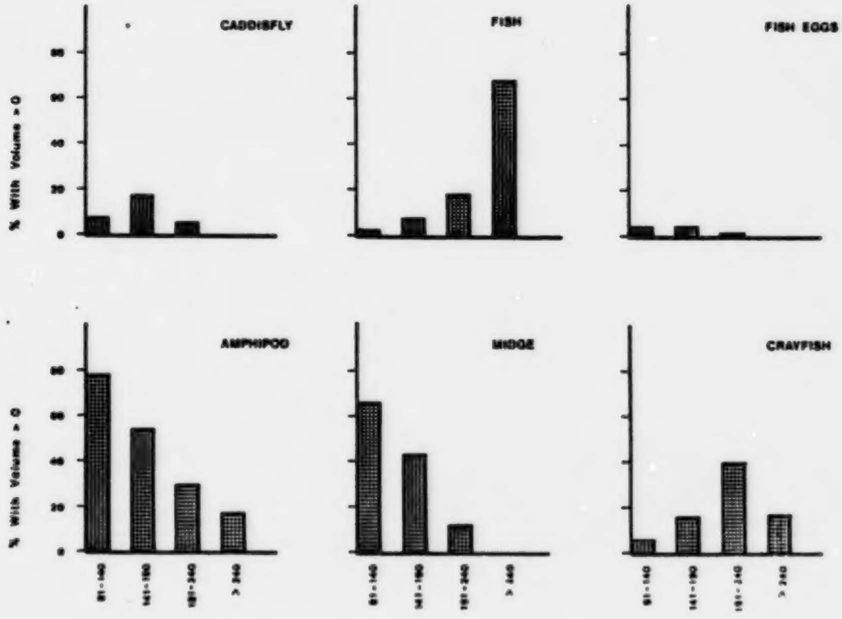
Table 4.1-9. Stomach contents of white bass, smallmouth bass and rock bass taken at Nanticoke, Long Point Bay, Lake Erie (1973-1983). Contents are expressed as frequency of occurrence (F), percentage of total number (N), percentage of total volume (V) and average of the volume percentages ($\bar{V}$).

| | WHITE BASS | | | | SMALLMOUTH BASS | | | | ROCK BASS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FOOD CATEGORY | % F | % N | % V | % $\bar{V}$ | % F | % N | % V | % $\bar{V}$ | % F | % N | % V | % $\bar{V}$ |
| Worms | 1.1 | 0.3 | T | T | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Snails | 1.6 | 0.5 | T | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Water Fleas | 1.1 | 25.4 | T | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Isopods | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.7 | 3.4 | 0.1 | 0.1 |
| Amphipods | 6.4 | 35.8 | 0.6 | 4.3 | 1.0 | 0.7 | T | T | 7.4 | 27.1 | 0.6 | 0.7 |
| Crayfish | 1.1 | 0.5 | 0.5 | 1.1 | 56.6 | 51.7 | 27.2 | 44.5 | 77.8 | 50.9 | 68.2 | 72.4 |
| Mayflies | 5.3 | 2.8 | 0.8 | 2.4 | 1.0 | 0.7 | 0.1 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Caddisflies | 1.1 | 0.8 | T | 0.6 | 1.0 | 0.7 | T | T | 0.0 | 0.0 | 0.0 | 0.0 |
| Midges | 6.9 | 7.3 | 0.2 | 3.4 | 1.0 | 0.7 | T | T | 0.0 | 0.0 | 0.0 | 0.0 |
| Other Arthropods | 3.2 | 5.1 | 0.3 | 1.9 | 0.0 | 0.0 | 0.0 | 0.0 | 3.7 | 1.7 | T | 3.7 |
| Fish Adults | 51.1 | 21.6 | 81.6 | 50.7 | 46.5 | 45.6 | 71.2 | 41.1 | 22.2 | 17.0 | 28.7 | 21.7 |
| Fish Eggs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Larval Fish | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Clams | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Other | 35.1 | -- | 14.5 | 37.7 | 14.1 | -- | 1.1 | 13.2 | 3.7 | -- | 0.7 | 0.7 |
| Debris | 2.1 | -- | 1.4 | 2.0 | 1.0 | -- | 0.4 | 0.1 | 7.4 | -- | 1.7 | 4.5 |

Table 4.1-10. Levins' (1968) Niche Breadth and Schoener (1970) dietary overlap values of yellow perch, white bass, smallmouth bass and rock bass taken during the operational period at Nanticoke, Long Point Bay, Lake Erie[1].

| | NICHE BREADTH | | | | SCHOENER OVERLAP INDEX | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SEASON | YELLOW PERCH | WHITE BASS | SMALLMOUTH BASS | ROCK BASS | YELLOW PERCH ON WHITE BASS | YELLOW PERCH ON SMALLMOUTH BASS | YELLOW PERCH ON ROCK BASS | SMALLMOUTH BASS ON ROCK BASS | SMALLMOUTH BASS ON WHITE BASS | ROCK BASS ON WHITE BASS |
| Spring | 2.478 | 2.328 | 1.590 | 2.255 | 0.255 | 0.103 | 0.160 | 0.637 | 0.758 | 0.521 |
| Summer | 8.194 | 4.157 | 3.037 | 1.000 | 0.432 | 0.341 | 0.213 | 0.574 | 0.607 | 0.181 |
| Fall | 3.975 | 1.665 | 3.657 | 1.321 | 0.244 | 0.553 | 0.465 | 0.652 | 0.668 | 0.319 |
| Pooled Seasons | 4.928 | 2.426 | 3.286 | 1.428 | 0.317 | 0.359 | 0.239 | 0.682 | 0.656 | 0.345 |

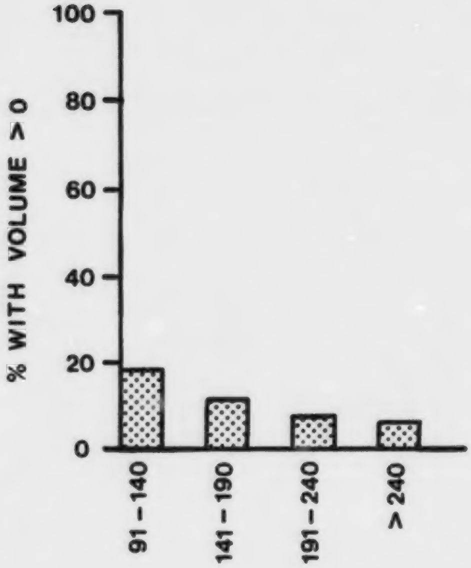
[1] Average of the volume percentages ($\bar{v}$) were used in these calculations.



| SOURCE OF VARIATION | df | AMPHIPODS | | MIDGES | | CRAYFISH | |
|---|---|---|---|---|---|---|---|
| | | $X^2$ | P | $X^2$ | P | $X^2$ | P |
| Intercept | 1 | 1.15 | 0.2839 | 7.84 | 0.0051 | 106.16 | 0.0001 |
| Length Class | 3 | 100.17 | 0.0001 | 82.12 | 0.0001 | 63.02 | 0.0001 |

| SOURCE OF VARIATION | df | CADDISFLIES | | FISH | | FISH EGGS | |
|---|---|---|---|---|---|---|---|
| | | $X^2$ | P | $X^2$ | P | $X^2$ | P |
| Intercept | 1 | 78.40 | 0.0001 | 120.39 | 0.0001 | 93.46 | 0.0001 |
| Length Class | 3 | 35.93 | 0.0001 | 94.43 | 0.0001 | 5.08 | 0.1663 |

Figure 4.1-1. Effect of length class on quantities of selected food items consumed by yellow perch at Nanticoke, Long Point Bay, Lake Erie (1974-1983).



| Source | df | $\chi^2$ | P |
|---|---|---|---|
| Intercept | 1 | 68.64 | 0.0001 |
| Length Class | 3 | 21.28 | 0.0001 |

Figure 4.1-2. Effect of length class on quantities of isopods consumed by yellow perch, Nanticoke, Long Point Bay, Lake Erie (1974-1983).

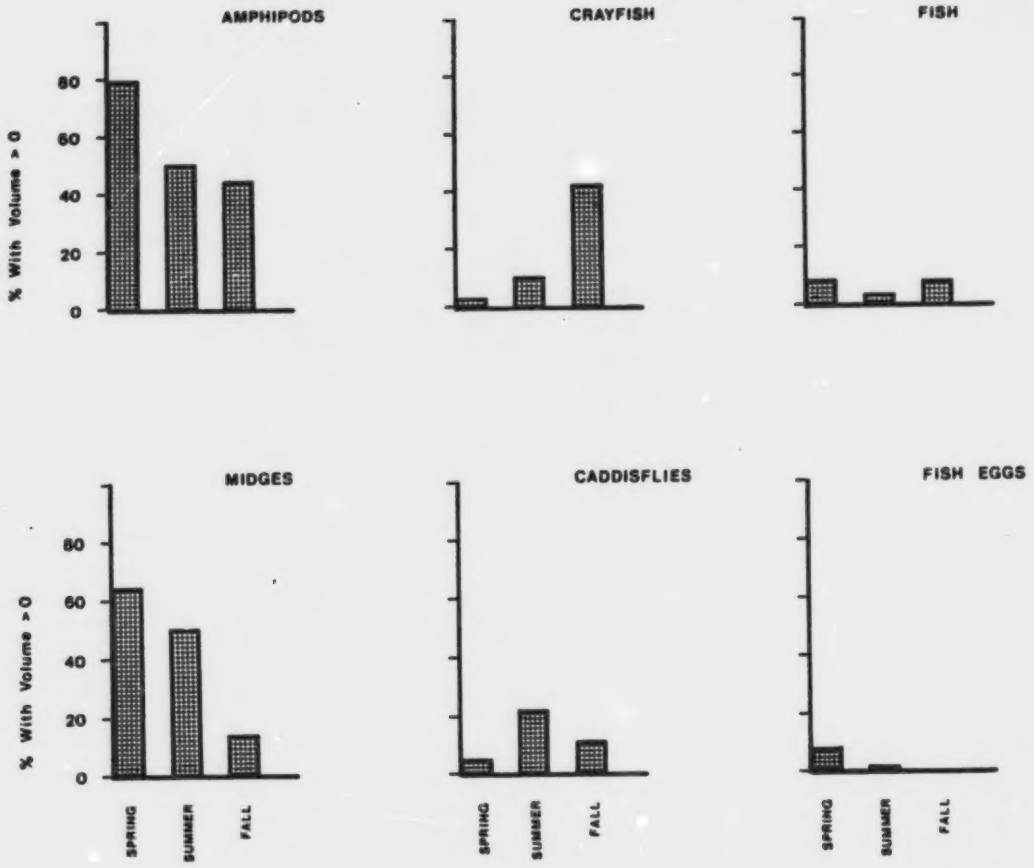


Figure 4.1-3. Seasonal trends in consumption of selected food items by yellow perch at Nanticoke, Long Point Bay, Lake Erie (1981-1983, pooled length classes, years and locations).

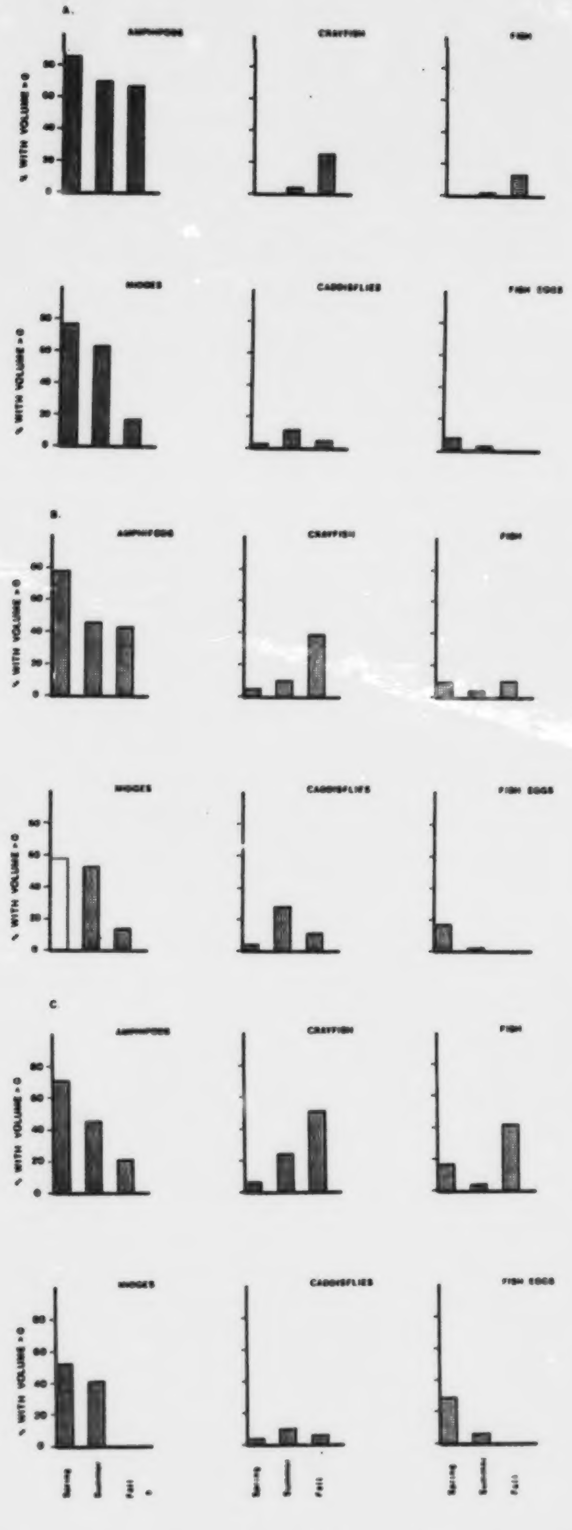
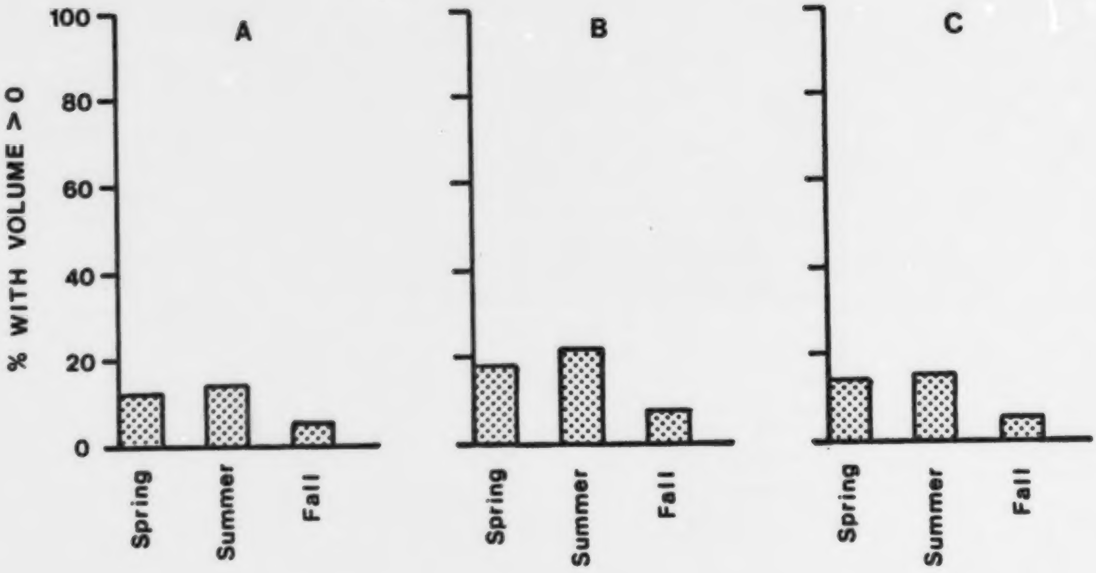


Figure 4.1-4 Seasonal trends in consumption of selected food categories by yellow perch at Nanticoke, Long Point Bay, Lake Erie (1974-1983; pooled locations and years).

A. 90-140 mm length class
B. 141-190 mm length class
C. 191-240 mm length class



| | | LENGTH CLASS | | | | | |
|---|---|---|---|---|---|---|---|
| | | 91-140 mm | | 141-190 mm | | Pooled | |
| Source | df | $\chi^2$ | P | $\chi^2$ | P | $\chi^2$ | P |
| Intercept | 1 | 421.28 | 0.0001 | 89.73 | 0.0001 | 567.94 | 0.0001 |
| Season | 2 | 12.58 | 0.0019 | 6.09 | 0.0477 | 27.23 | 0.0001 |

Figure 4.1-5. Seasonal trends in consumption of isopods by yellow perch at Nanticoke, Long Point Bay, Lake Erie (1974-1983; pooled locations and years). A = 90 - 140 mm, B = 141 - 190 mm, C = 191 - 240 mm.

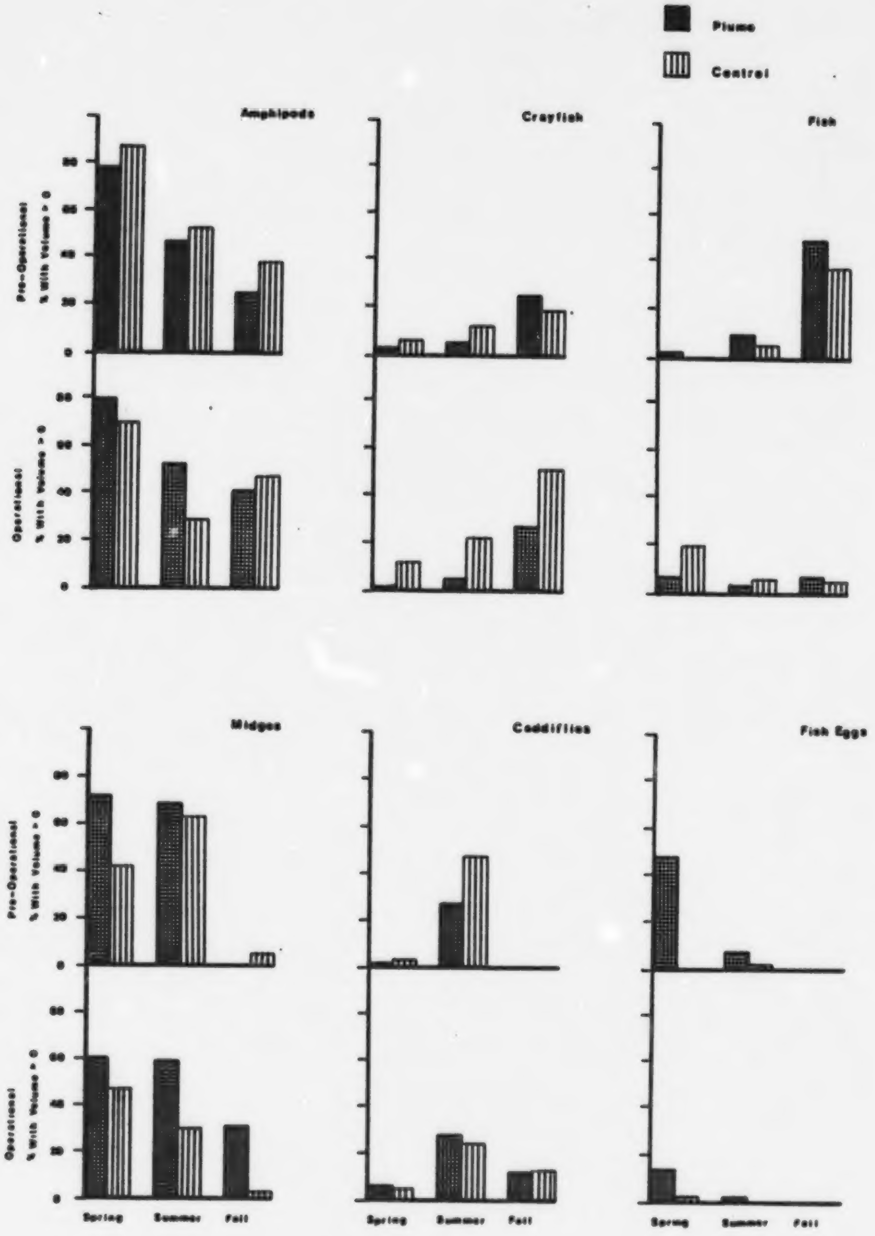


Figure 4.1-6. Effects of location and season on consumption of selected food items by yellow perch at Nanticoke within the preoperational and operational periods (1974-1983, 141-190 mm length class).

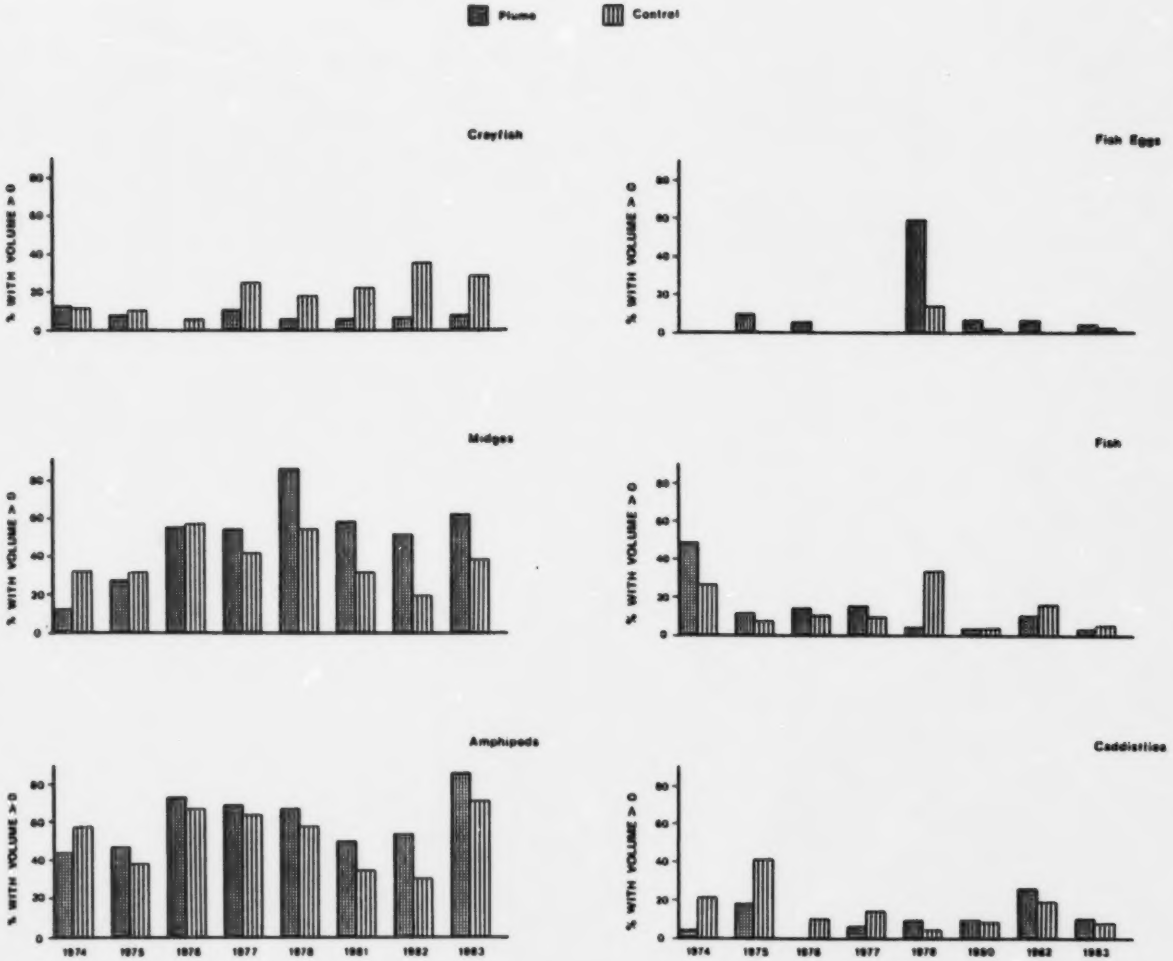
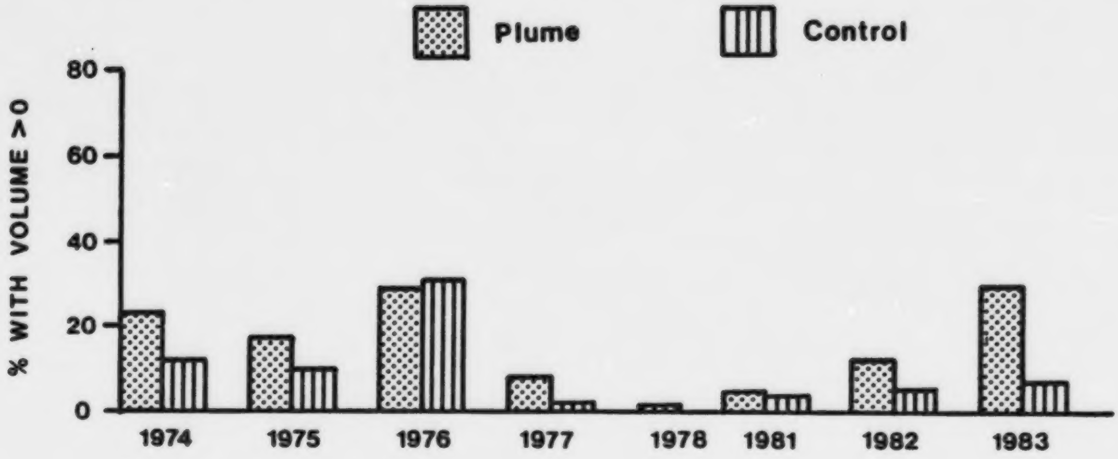


Figure 4.1-7. Yearly trends in consumption of selected food categories by yellow perch at Nanticoke, Long Point Bay, Lake Erie (1974-1983, 141-190 mm length class).



| Source of Variation By Period | | df | LENGTH CLASS 141-190 mm $\chi^2$ | P | Pooled $\chi^2$ | P |
|---|---|---|---|---|---|---|
| 1974-1978 | | | | | | |
| Intercept | | 1 | 63.75 | 0.0001 | 126.32 | 0.0001 |
| Main Effects: | Year | 4 | 12.38 | 0.148 | 21.89 | 0.0002 |
| | Location | 1 | 0.02 | 0.89 | 0.13 | 0.7215 |
| Year x Location | | 4 | 3.16 | 0.5313 | 3.92 | 0.4164 |
| 1981-1983 | | | | | | |
| Intercept | | 1 | 277.86 | 0.0001 | 458.23 | 0.0001 |
| Main Effects: | Year | 2 | 14.57 | 0.0007 | 23.73 | 0.0001 |
| | Location | 1 | 11.85 | 0.0006 | 13.24 | 0.0003 |
| Year x Location | | 2 | 3.88 | 0.1440 | 6.88 | 0.0321 |

Figure 4.1-8. Yearly trends in consumption of isopods by yellow perch at Nanticoke, Long Point Bay, Lake Erie (1974-1983) (Histogram includes only the 141-190 mm length class).

## 4.2 REPRODUCTION

### 4.2.1 Spawning areas

Introduction

The sequence of events relating to reproduction (gonadal development and maturation, spawning migration and spawning, development of eggs and embryos, etc.) are among the most complex in fish life history and are generally the most thermally sensitive of all life stages (Brett 1970, NAS 1973). Abnormal temperature fluctuations (such as the thermal discharge from power plants with fluctuating power outputs) appear to be of great significance in reduced production of juvenile fish (NAS 1973). As fish may spawn in the NTGS discharge channel, or in areas affected by other industrial effluent, identification of spawning and nursery grounds and monitoring aspects of fish reproduction near the various discharges of the Nanticoke Industrial Complex were initiated.

Methods

Many attempts have been made to identify spawning areas of important fish species within Long Point Bay, but the information is scattered and tends to emphasize Inner Bay. Descriptions of spawning areas and spawning times within this report are based on a variety of technical documents, theses, inferences from data, and personal communications. In addition, the NFS has carried out specific short-term investigations in an attempt to locate spawning areas of economically important species in the Nanticoke area. These investigations were categorized into two groups: 1) general surveillance of fish spawning in the Nanticoke area, 2) detailed surveillance of rainbow smelt spawning in the NTGS outfall and Centre Creek (receiving stream for Stelco's effluent).

## A. General Surveillance

The objective of our general survey was to identify major areas of fish spawning within the nearshore waters from Centre Creek to Peacock Point (Figure 4.2.1-1). Surveillance was targeted on rainbow smelt, yellow perch, and smallmouth bass, all of which are spring spawners.

A combination of three techniques was employed. Egg collections of rainbow smelt and yellow perch were attempted with a modified demersal sled apparatus (Figure 4.2.1-2) and a 6.1-m bottom otter trawl (perch eggs only). Underwater surveillance with scuba was used to supplement observations of yellow perch spawning and was the only practical method of determining smallmouth bass spawning areas.

The demersal sled consisted of a vertically adjustable steel hoop attached to two steel skis. A standard 0.5-m plankton net (782 mesh) shortened to 1.4 m was fastened to the steel hoop. Several lengths of steel chain were fastened across the net opening to dislodge smelt eggs from the lake bottom and allow them to be swept into the plankton net. The chains were removed during sampling for perch eggs.

Sampling with the demersal sled and otter trawl were attempted periodically in April and May, 1982 - 1983. Duration and distances of tows were not standardized. Instead, only the absence or presence of eggs was noted with sampling effort determined largely by available time, weather, and bottom conditions.

Underwater observations were made by two scuba divers from early May to early July, 1983. Dive sites were confined primarily to nearshore areas of Centre Creek, the NTGS, the Oneida - Peacock Point area, and 1-mile reef (Figure 4.2.1-1). Two underwater surveillance techniques were employed: transect and free dives. A transect was a 183-m rope anchored on bottom and marked with a float on surface at both ends. Divers were tethered adjacent to each other on the transect rope and swam a parallel course at a maximum visible distance (determined by water clarity and light intensity) from the transect line. Divers looked for egg masses of yellow perch and for evidence of smallmouth bass spawning (nests, guarding males, black fry). Divers noted the predominate sediment type and relative suitability of the lake bottom for smallmouth bass spawning. Pertinent underwater observations and measures of water temperature and secchi depth were recorded.

### B. Smelt Spawning in the NTGS Outfall and Centre Creek

Stomach content analyses of fish captured in the vicinity of the NTGS outfall revealed that large numbers of rainbow smelt eggs were consumed by a variety of fish species in 1978 near the NTGS outfall (see section 4.1). As these observations suggested that smelt may mistake the discharge channel for a spawning stream this possibility was examined in 1982 and 1983 by means of a gillnet survey, underwater surveillance and sled tows. In addition, we examined the possibility of smelt spawning in Centre Creek.

### (i) Gillnet Survey

The gillnet survey began in the spring of 1982, and was revised and upgraded in 1983. The objectives of the survey were to investigate the possibility of mature rainbow smelt concentrations at the NTGS discharge channel and Centre Creek during the spawning season.

In 1982, index gangs of gillnet (comprised of 1.5-m nets each of 25-mm, 32-mm, and 38-mm stretched mesh gillnet) were set at four 'test' locations (100-103) in the vicinity of the NTGS discharge channel and at two reference locations (104-105) removed from the immediate influence of the discharge (Figure 4.2.1-3). At each location, the nets were set twice per week from March 30 to May 27, 1982, and lifted the following day (weather permitting). A similar netting program was carried out in 1983, but each gang consisted of 4.6-m foot panels each of 25-mm and 38-mm stretched mesh monofilament gillnet. Index gangs were set again at the same four 'test' locations and two reference locations; however, an additional two reference locations (108, 109) were added in 1983 (Figure 4.2.1-3). At each location, the nets were again set twice per week for 7 weeks (March - May , 1983) and lifted the following day.

Similar nets were set at Centre Creek to enable detection of mature smelt concentrations near the receiving stream for Stelco's effluent. In 1982, a net was set at location 106, and in 1983 nets were set at locations 106 and 107 (Figure 4.2.1-3). Hereafter, all locations exclusive of 106 and 107 will be referred to as 'Nanticoke test (100 - 103) or reference (104, 105, 108, and 109) sites', whereas 106 and 107 will be referred to as 'Centre Creek test sites'.

In both years vertical temperature profiles were recorded (one metre intervals) at each location on each lift day. In addition, we calculated comparable weekly and daily mean intake and discharge temperatures for the NTGS from hourly temperature data provided by Ontario Hydro. Intake temperatures likely are most reflective of ambient water temperatures experienced by smelt before they move inshore to spawn.

All fish species captured in each mesh size at each location were counted and returned to the laboratory in Port Dover for further processing. In 1982, subsamples of 15 smelt were selected randomly from the total catch of each mesh size at each location. Each fish from each subsample was weighed to the nearest gram (Toledo Computagram Scales Model 3710), measured to the nearest millimeter for fork and total lengths, and its sex and state of gonadal maturation established by dissection and visual inspection. Scales were taken from each fish near the insertion of the dorsal fin, mounted, and the scale age determined on a trichinoscope microprojector by staff of the Lake Erie Fisheries Assessment Unit in Wheatley, Ontario. All fish species captured in 1983 were sorted again according to mesh size and returned to the laboratory for further processing. Forty-eight rainbow smelt were selected randomly from the entire catch at each location and sampled as in 1982.

Most data from the gillnet surveys were summarized and examined as weekly means based on the following schedules:

| 1982* | | | 1983 | | |
|---|---|---|---|---|---|
| Week No. | Week Beginning | Sampling Dates | Week No. | Week Beginning | Sampling Dates |
| 1 | March 28 | March 30,31 | 1 | March 27 | March 30 |
| 2 | April 4 | April 4 | 2 | April 3 | April 6,8 |
| 3 | April 11 | April 11 | 3 | April 10 | April 12,15 |
| 4 | April 18 | April 20,22 | 4 | April 17 | April 19,22 |
| 5 | April 25 | April 27,28 | 5 | April 24 | April 26,29 |
| 6 | May 2 | May 4,5 | 6 | May 1 | May 4,6 |
| 7 | May 9 | May 11,12 | 7 | May 8 | May 11,12 |
| 8 | May 16 | May 18,19 | | | |
| 9 | May 23 | May 26,27 | | | |

**In 1982, surveillance at Centre Creek (loc 106) did not begin until week 4 and was curtailed in week 8.*

Weekly mean temperatures of Hydro's intake and discharge water were based on 7-day averages for the respective week number (based on week beginning dates in the above schedule).

### (ii) Smelt Egg Survey

Collections of smelt eggs were made to provide direct evidence of egg deposition and relative egg density. Standardized and replicated (3 x) demersal sled tows were carried out on April 22 and April 29, 1983 at four joint 150- to 200-m linear transects through the NTGS outfall. Transects coincided with the gillnet locations depicted in Figure 4.2.1-3:

transect A was from net location 100 to 101,
transect B was from net location 101 to 102,
transect C was from net location 102 to 103, and
transect D was from net location 103 to 150 - 200 m southeast of net location 103

At the end of each tow, contents were washed from the net into a labeled jar. In the laboratory, egg samples were counted and their developmental stage classified as pre-eyed or eyed.

Absence or presence of smelt eggs in Centre Creek was determined by periodic inspection of stream gravels in April - May, 1982. To better quantify relative egg densities in 1983, artificial substrates were placed in the lower section of Centre Creek where egg deposition was previously observed. Initially, concrete construction blocks were used, but these were too conspicuous as smelt netters usually removed them prematurely from the stream. Steel plates (painted black), approximately 20 cm square proved to be a satisfactory alternative. Plates were usually inspected every day; those containing smelt eggs were immersed in water and transported to the laboratory for counts and microscopic examination to determine stage of developement. Clean plates were installed to replace those removed. Absence/presence of smelt eggs in Centre Creek's outfall (mixing zone) was examined by non-standardized tows with the demersal sled.

## Results

Only results of the field surveillance programs are reported here; results of literature reviews are included in the discussion.

### A. General Surveillance

The demersal sled functioned effectively for smelt eggs on relatively smooth surfaces. It also proved effective in collecting yellow perch eggs in Inner Bay, which has a flat bottom and a high density of perch spawners. The suitability of the sled for collecting eggs of either smelt or perch in Nanticoke, however, was restricted to only a few locations because of rocky bottom conditions. For the same reason sampling perch eggs with a bottom otter trawl at Nanticoke was also severely restricted.

Smelt eggs were collected in the NTGS plume in 1982 and 1983 (Table 4.2.1-1), but no other areas sampled with a demersal sled produced smelt eggs. Sampling with a demersal sled and otter trawl and by underwater surveillance also showed no evidence of yellow perch spawning (Table 4.2.1-2). Observations by scuba divers indicated that spawning habitat for smallmouth bass in the nearshore (1 km) waters of Nanticoke was fair to poor. Rock predominated throughout the areas surveyed, whereas gravel and sand were scarce. The bottom sediments in many shallow areas (<4 m) were covered by a dense mat of attached algae (probably Cladophora spp.). Macrophytes and other rooted aquatic vegetation were sparse or absent. Of the areas surveyed, bottom habitat appeared to be the best for smallmouth bass spawning on 1-mile reef; large concentrations of smallmouth bass and at least one nest were observed there.

Poor water clarity was a major factor impeding underwater surveillance, particularly near shore where bottom visibility rarely exceeded 2 m (Table 4.2.1-2).

## B. Smelt Spawning in the NTGS Outfall and Centre Creek

### (i) 1982 Gillnet Survey

A total of 1,094 fish (representing 12 species) were captured in 1982 at the six Nanticoke gillnet sites, of which 845 (77.3%) were mature rainbow smelt. Some 88% of the total catch and 92% of the rainbow smelt were taken at the four 'test' sites (100-103) near Hydro's discharge. Locations 100 and 101 (the two sites closest to the discharge channel) produced 59.3% of the total catch and 63.7% of the rainbow smelt captured. Catches of smelt at all locations varied considerably among weeks. Peak catches occurred in weeks 6 and 7 at mean intake temperatures of 6 and 7°C respectively (Figure 4.2.1-4). Mean discharge temperatures were 9 and 13°C respectively in those weeks. Smelt catches were considerably smaller at the Centre Creek test site but they also peaked in week 6. Smelt catches exhibited a smaller rise in week 4 at most test sites when mean discharge temperatures rose to 10°C but catches dropped considerably in week 5 when temperatures fell to 8°C (Figure 4.2.1-4).

The majority (71%) of smelt in the gillnet samples (pooled locations) were males through most of the sampling weeks; their numbers tended to peak earlier than females (Figure 4.2.1-5). While the overall catch of smelt peaked in week 6 and declined thereafter, the proportion of females continued to increased from weeks 6 through 8 (Figures 4.2.1-5).

Some 82% of the ripe males sampled over the study period were captured in weeks 6 and 7, although ripe males were captured as early as week 1 (Figure 4.2.1-6). Ripe females were taken as early as week 2 but the majority (54%) were taken in weeks 6 and 7 (Figure 4.2.1-6). Spent smelt of both sexes were first detected in week 6, when most spent males and females (59% and 71% respectively) were taken. Spent fish of both sexes persisted in the samples through week 8 (Figure 4.2.1-6).

The 1979 year-class (age 3) was dominant in the 1982 catches and averaged 84.5% of the total catch over all locations. Mean lengths, weights and year-class composition of the 1982 smelt catch are summarized in Table 4.2.1-3 by age and sex.

### (ii) 1983 Gillnet Survey

In 1983, a total of 4,508 fish (representing 16 species) were captured at the 8 Nanticoke sites, of which 2,894 (64.2%) were mature rainbow smelt. Some 63.6% of the total rainbow smelt catch was taken at the four Nanticoke 'test' sites. Locations 100 and 101 (closest to the discharge channel) produced 44.8% of the total rainbow smelt catch. Catches of smelt again varied considerably among weeks and locations, but in this year many of the reference locations also exhibited high catches (Figure 4.2.1-7). Peak catches at most locations occurred in week 3 at mean intake and discharge temperatures of 6 and 12°C, respectively.

Smelt catches at the Centre Creek test sites generally were lower than those at the Nanticoke test sites, and lower even than those at the reference sites. Peak catches at Centre Creek did not occur until weeks 4 or 5 (Figure 4.2.1-7).

Similar to the 1982 catches, the majority (87%) of smelt sampled from the 1983 catches were males, although the proportion of females rose steadily over the sampling period (Figure 4.2.1-5). This pattern was much more evident in 1983 than in 1982 possibly due to better and larger samples collected in 1983. Some 96% of the ripe males and 93% of the ripe females sampled over the study period were captured in weeks 3 through 5, although ripe males and females were first detected in weeks 2 and 3 respectively (Figure 4.2.1-8). Weeks 4 and 5 accounted for the bulk of spent males and females (83% and 79%, respectively) sampled over the study period, although spent fish of both sexes persisted in the samples through week 7.

The 1981 year-class (age II) was dominant in the 1983 catches, and averaged 86.4% of the total catch over all locations. Mean lengths, weights and year-class composition of the 1983 smelt catches are summarized by age and sex in Table 4.2.1-4.

### (iii) Smelt Egg Survey

Smelt eggs were collected in the NTGS outfall as early as April 18 (1983), and as late as May 26 (1982) (Table 4.2.1-1). Standardized sled tows through the NTGS outfall showed that egg densities tended to decrease with distance from the outfall (Table 4.2.1-5).

First observations of smelt spawning in Centre Creek were on April 30 in 1982 and April 19 in 1983 (Table 4.2.1-6). Peak Egg deposition in Centre Creek in 1983 occurred approximately on April 26. No smelt eggs were found (sampled with a demersal sled) in the outfall of Centre Creek (Table 4.2.1-1).

## Discussion

### A. Smelt Spawning in the NTGS Outfall and Centre Creek

The 1982 and 1983 gillnet surveys demonstrated rather clearly that mature rainbow smelt concentrate near the NTGS outfall during spawning. In both years, smelt catches at the Nanticoke test sites tended to decline with distance from the discharge channel (Figure

4.2.1-9). The low 1982 catches at location 100 are attributed to difficulties encountered in maintaining the net in the fast current (ie. the net tended to move, twist or tear). This problem was overcome in 1983 when new, larger nets and a better anchoring system were employed.

That the observed concentrations of smelt at the NTGS were, in fact, spawning was confirmed by the collection of smelt eggs in the discharge channel and plume at the same time. Similar to the observed decline in smelt catches with distance from the discharge channel, smelt egg density also declined with distance suggesting that most spawning took place within or near the channel (it is probable that some eggs were swept out of the channel following their release and deposited on bottom some distance from the channel). Our indirect evidence of substrate conditions in the NTGS test area indicated that most eggs were deposited over stone, gravel and/or coarse sand mixed with coal granules within 100 m or so of the channel (Figure 4.2.1-10). Clean gravel, coarse sand or boulders may be the preferred spawning substrate (Rupp 1959), and on this basis substrate conditions beyond the first 100 metres outside the channel were less suitable, being comprised principally of silt, sand and mud. We suspect that most smelt spawning occurred immediately outside the discharge channel on a bed of sand, gravel and coal particles.

Smelt spawning at the NTGS appears to be in agreement with observations at more typical sites for the species. In both years smelt tended to move into the test sampling areas when ambient water temperatures approached 7°C (Figure 4.2.1-11), the temperature which most of the Lake Erie population tends to occupy (Hart and Ferguson

1966). Spawning activity peaked (as judged by the appearance of spent fish) when discharge temperatures averaged 9°C in 1982 (week 6) and some 12°C in 1983 (week 5). Scott and Crossman (1973) suggest that spawning runs do not usually begin in the earliest streams until temperature reach 8.9°C and late spawners in the Miramichi River usually leave before temperatures reached 15°C (McKenzie 1964). At Nanticoke, discharge temperatures in 1982 rose steeply from 12°C in week 7 to 18°C in week 8 and smelt catches declined to near zero over the same period. In 1983, smelt catches dropped steeply between weeks 5 and 6 when temperatures rose from 12°C to 15°C (Figure 4.2.1-4, -7,-11).

The early arrival of males as observed in our study has been noted elsewhere (Greene 1930, Ferguson 1967). The predominance of males in the catches during the spawning week(s) is likely an artifact of our sampling design as gillnet catches were based on 24 hour sets. Smelt typically spawn at night and only the males are reported to remain in the spawning area during the day; females, on the other hand, move in only at night (Hoover 1936). The sex ratio of males to females fluctuates dramatically over the course of one night and have been observed to range from 261:2 to 15:30, then back to 103:0 in a single spawning night (Hoover op. cit). Consequently, females may have been vulnerable to our nets at Nanticoke over a much shorter duration than were the males (which may remain in the spawning area over the entire set duration). Smelt observed schooling in Centre Creek during the day were sampled and found to be predominantly males (of 200 rainbow smelt sampled from Centre Creek during the day on April 30, 1982, only 19 were females, the ratio of males:females being 8.4:1).

Our observations confirm that conditions at the NTGS discharge provided suitable stimuli for smelt spawning. The occurrence of numerous well developed eyed eggs in the discharge channel suggest that conditions here also were suitable for egg development.

Rainbow smelt were observed to concentrate and spawn successfully at Centre Creek (Figure 4.2.1-12), although smelt catches in the Centre Creek nets were considerably lower than at the NTGS. The observed concentration of smelt in Centre Creek, the deposition of eggs on natural and artificial substrates in the creek, and the occurrence of well developed eyed eggs suggest that conditions here also were suitable for smelt spawning and egg development, despite industrial effluent draining into the stream from Stelco.

## B. General Description of Spawning and Nursery Areas in Long Point Bay

Brown trout, brook trout, coho salmon, chinook salmon, and more recently, pink salmon (odd-year runs) are known to spawn in the fall in several coldwater tributaries draining into Long Point Bay (including Big Creek, Normandale Creek, Fisher's Creek and Young's Creek). There is some doubt that chinook and coho salmon are self-sustaining in Long Point Bay; rather, their abundance appears to be related to annual plantings in Lake Erie by the United States. While pink salmon presently are not planted anywhere in the Great Lakes and are doubtless self-sustaining within the Great Lakes as a whole, the success of pink salmon spawning in Long Point Bay remains in question (pers. comm. D.J. Reid). Rainbow trout spawn successfully in the abovementioned Long Point Bay tributaries, but annual plantings are important in regulating their abundance. Pink salmon, rainbow trout and coho salmon have been observed periodically by OMNR biologists and anglers in Centre Creek, but spawning here by these species is not confirmed.

Inner Bay and the south shore of Long Point are of great importance as spawning/nursery areas for a wide variety of fish species (Goodyear _et al_. 1982) including such important ones as yellow perch, northern pike, smallmouth bass, largemouth bass, and many other centrarchid species (Reid 1976, 1978; Whillans 1977, Goff 1984, Pynenburg and Witzel 1985). The shallow waters and extensive, productive marshlands here provide excellent habitat for fish spawning (Goff 1984). Shelter and food is abundant in these areas, providing prime nursery areas for young fish.

Northern pike spawning occurs primarily in the western areas of Long Point Bay where spawning runs are extensive in late March or early April. Spawning occurs in most of the shallow marsh areas of Inner and Long Point Bays, and in the lagoon areas of Long Point (Goodyear _et al_. 1982). Some limited pike spawning may also occur in the marsh areas at the mouth of Nanticoke Creek.

Smallmouth bass migrate westward along the north shore of Long Point Bay into Inner Bay (Kelso 1973b) where the majority of the known spawning grounds occur, although resident stocks are expected to exist within the Inner Bay and along the shores of Long Point. The major near-shore spawning grounds appear to be over sandy bottom along the leeward shore of Inner Bay, through Sturgeon Bay eastwards to and around Pottohawk Point to Bluff Point, smaller spawning areas are thought to occur in the vicinity of Bait Island, Turkey Point and at

Nanticoke (Goff 1984, Sztramko 1985, Kelso 1972). Sztramko (1985) suggests that, with the exception of Inner Bay and the south shore of Long Point, most of Long Point Bay could be excluded as being undesirable habitat due to unsuitable substrates, relative length of windward shoreline, and distance from shore exposed to strong currents or wave action. However, smallmouth bass have been known to spawn in the Nanticoke study area (Kelso 1972); and smallmouth bass spawning has been confirmed in the NTGS discharge channel (see Section 3.2.5). In 1982 and 1983 our creel census crew observed several smallmouth bass nests in quiet areas along the west wall of the channel. These nests subsequently produced black fry. In 1984 many more smallmouth bass nests and black fry were observed in the channel by Ontario Hydro divers (Balesic 1986). Important spawning areas for this species at Nanticoke may be in the offshore shoals (eg. 1-mile and 3-mile reefs) where spawning habitat was the best we observed of any areas examined in the Nanticoke study area.

Egg collections made during two lake-wide surveys of smelt spawning in Lake Erie documented spawning along much of the northern shore of the central and eastern basins of Lake Erie (Goodyear et al. 1982; MacCallum and Regier 1970). Many spawning areas within Long Point Bay were noted in these surveys. Most smelt spawning within Lake Erie occurs on beaches and shoals at depths of 3 m or less, although several stream spawning areas are known in Long Point Bay (Normandale, Fisher's and Young's Creeks). Spawning also occurs along several beach areas in Long Point Bay, including Turkey Point, Fishers Glen, Port Dover, Pottohawk Point and Long Point. MacCallum (1969) speculated that the major spawning areas must occur in the vicinity of

Long Point where sampling was precluded due to inclement conditions. Rainbow smelt eggs have been collected off the tip of Long Point (MacCallum and Regier 1970) and some commercial fishermen claim that smelt spawning occurs in deep water of the open lake. Ferguson (1963) collected smelt eggs in up to 10 m of water some 2 km offshore of Wheatley harbour and deep water (>9 m) spawning by smelt is the common situation in Lake Champlain where most intense egg deposition occurs at depths of 17-23 m (Plosila, 1984). We have established that rainbow smelt spawn successfully in the NTGS discharge channel and in Centre Creek. The size of the spawning runs to these two sites relative to those at other spawning areas is unknown but expected to be small.

The western basin is the major spawning and nursery area for Lake Erie yellow perch (Goodyear et al. 1982). Within Long Point Bay, the Inner Bay is a major spawning area (Environ. Can. 1977) and large "carpets" of yellow perch eggs have been observed throughout Inner Bay by divers from the University of Western Ontario. Spawning presently occurs along the south shore of Long Point Bay and on Long Point, where yellow perch run into the lagoons in early April and May. Spawning also occurs along the north shore of Inner Bay from Port Rowan to St. Williams (Whillans 1977) and experimental diving and sled tows carried out by NFS biologists have confirmed egg deposition in the St. Williams area and along the south shore of Inner Bay. Some spawning may also occur along the north shore of Long Point Bay (Goodyear et al. 1982, Hamley and MacLean 1979).

Although mature, ripe yellow perch tend to concentrate near the NTGS outfall and Centre Creek in the spring (see Section 3.2.4), we (1982 -

1983) found no evidence (by direct observation of egg deposition) of perch spawning there or. elsewhere in the Nanticoke study area. However, Scrutton (1978) found three yellow perch egg masses between 100 and 300 m offshore of Centre Creek. Our same methods did produce significant numbers of perch egg masses in the Inner Bay. Some evidence of perch spawning within the study area is provided by consistent, although small, catches of larval perch in our standardized larval tows carried out between 1971 and 1983. In addition, standardized trawl sampling performed throughout Long Point Bay produced small catches of young-of-the-year (YOY) yellow perch at Nanticoke [see Witzel (1983) for descriptions of trawling methods and locations]. However, both larval tows and trawling produced much larger catches of larval and YOY perch in western areas of Long Point Bay (particularly Inner Bay) (Table 4.2.1-7, Figure 4.2.1-13).

Most spawning by white bass appears to occur in the western and central basins of Lake Erie, although the species has been known to spawn in Long Point Bay since 1888 (Goodyear _et al_. 1982). White bass larvae have been found at the generating station (Teleki 1976), and large concentrations of adult white bass are now common each spring in the NTGS discharge channel and plume (see Section 3.2.4). Underwater surveillance carried out by Ontario Hydro divers confirms that spawning by this species in the discharge channel now occurs (Balesic 1986). Young-of-the-year white bass have been collected by OMNR trawling surveys since 1979 and while they occur in nearshore areas throughout Long Point Bay, they appear more numerous along the south shore of Long Point and Turkey Point.

Rock bass passing through Nanticoke waters undertake a 35 - 40 km spring spawning migration along the north shore of Long Point Bay to Inner Bay (MacLean and Teleki 1977), and YOY rock bass have been found only in or near Inner Bay (Hamley and MacLean 1979, Teleki *et al.* 1977, Reid 1978). In addition, reproducing populations of rock bass probably are established in lagoons on Long Point.

Rugged bottom conditions and turbid waters likely reduced the efficiency of most of our sampling methods in Nanticoke waters. Only a small fraction of the nearshore waters fronting Nanticoke were sampled by sled tows and scuba diving. The range and intensity of our sampling, therefore, may not have been sufficient to detect low densities of spawning by most species. Another consideration is that spawning habitat was generally unsuitable for the species concerned; we observed a distinct lack of aquatic vegetation and granular sediments of the sizes preferred by yellow perch and smallmouth bass (Scott and Crossman 1973, Dorr 1982).

In summary, although spawning by several commercially or recreationally important fish species (eg. yellow perch, rainbow smelt, smallmouth bass, white bass) occurs in Nanticoke waters, the existing evidence, while tentative, suggests that spawning by such species may be more concentrated in areas removed from the Nanticoke study area (particularly in Inner Bay). Spawning by several species has been confirmed within the NTGS discharge channel and Centre Creek, but the extent of spawning here relative to other areas in Long Point Bay is expected to be small.

### 4.2.2 Yellow Perch Fecundity

#### Introduction

Annual fluctuations in the number of eggs produced per female (fecundity) have been related to population density, temperature, food supply and other environmental effects (Bagenal 1973, 1978; Hodder 1965; Hokanson 1977; Scott 1962). As environmental factors can influence fecundity, studies of fecundity variation in key fish species have potential value in assessing industrial effects. For this reason, we have monitored the fecundity of yellow perch in Long Point Bay since 1974. In addition, attempts were made to examine smallmouth bass fecundity in Long Point Bay, but small sample sizes and the propensity of this species towards partial spawning (Berst 1953, Reynolds 1965) precluded any detailed statistical analyses of the results (Sztramko and Hamley 1981).

#### Methods

Methods used since 1979 have been the same as those described by Sztramko and Hamley (1981) and Sztramko and Teleki (1977), and are summarized below. Mature female yellow perch were collected from 1974-1983 immediately prior to the spawning periods (no sampling was carried out in 1979 and 1980). Sampling sites were located in the vicinity of the industrial complex at Nanticoke.

Fish samples were usually collected from the standard Nanticoke trap nets. Each fish was measured for weight (nearest 0.1 g) and fork length (nearest 1.0 mm). Scales were collected from a region near the tip of the left pectoral fin when depressed for subsequent determination of scale age.

Absolute fecundities per female were determined by the gravimetric wet subsample method (Bagenal and Braum 1968). Each excised ovary was weighed after removing excess fluid on filter paper, and eggs from two ovary subsamples were counted on a grid and weighed to the nearest 0.1 mg. To ensure fecundity comparisons of similar sized fish, subsamples of 33 fish were taken from each year's collection using the following length-frequency distribution of the smallest sample (1974);

| Fork Length (mm) | N |
|---|---|
| 180-199 | 5 |
| 200-219 | 8 |
| 220-239 | 9 |
| 240-259 | 5 |
| 260-279 | 3 |
| 280-299 | 2 |
| 300-319 | 1 |

This standardization of size distribution was necessary as regressions of fecundity on fish length are influenced by the length-frequency distributions of the samples (Sztramko and Teleki; 1977). Covariance analysis (ANCOVA, Snedecor and Cochran 1980) was used to test for differences among yearly or location - location fecundity levels.

In 1982 and 1983 additional samples were collected to enable comparisons of fecundity among locations. Yellow perch fecundity at Nanticoke was compared with the fecundity of perch collected in the Inner Bay. In addition, the fecundity of yellow perch taken at the

NTGS plume was compared with that of yellow perch collected at sites removed from the plume influence.

Gonadal development was described by periodically calculating maturity indices from female fish collected over the entire year. Maturity index was calculated as the total ovary weight divided by total body weight (Vladykov 1956).

## Results

### A. Ovary Development

Maturity index data collected in 1983 suggests that values were highest in April just before spawning (mean = 25.4%; range = 15-37.5%). A post-spawning minimum average maturity index of 0.7% (0.2-1.6%) was recorded in July and the indices increased thereafter, to average 4% by October. In earlier years, average maturity indices of some 12% and 19% were recorded in December and March respectively.

### B. Fecundity

The relationships between fecundity and fork length, ovary weight and body weight are described in Table 4.2.2-1 for each study year. Fecundities ranged from 3,425 eggs in a 129 mm female to 156,006 eggs in a 338 mm female, and show considerable variation even among similar sized fish. Because of a poor fit ($r^2 = 0.67$, Table 4.2.2-1) in the 1981 regression of fecundity on fork length, 1981 data were dropped from further analysis (a methodological error was suspected but the data could not be adjusted to compensate for it).

Analysis of covariance revealed highly significant differences (P = 0.0137) among years in the adjusted mean fecundities; however, the slopes of the yearly fecundity - fork length regressions were not significantly different (Table 4.2.2-2). The adjusted mean fecundity was highest in 1974, then dropped by 16% to the lowest value in 1975. Fecundity has increased steadily since 1975 (Figure 4.2.2-1). The high 1974 value and low values in 1975 and 1976 seem to explain most of the statistical differences detected among years (Table 4.2.2-3). To provide a more meaningful comparison of annual fecundity, the fecundity of an average 228-mm perch was estimated from the yearly log - log regression of fecundity on fork length (Table 4.2.2-4, Figure 4.2.2-1).

Comparisons among locations revealed no significant difference in yellow perch fecundity at Inner Bay or at the NTGS plume when compared to other reference areas at Nanticoke (Tables 4.2.2-5, 4.2.2-6).

### Discussion

Yellow perch fecundity in Long Point Bay ranged from 3,245 eggs to 156,006 eggs per female, and fall within the range reported by Thorpe (1977a) for this species in other North American waters. The adjusted mean fecundities differed significantly among years, but the differences detected would seem to be due largely to the high value in 1974 and low values in 1975 and 1976. The observed year-to-year variations in fecundity of Long Point Bay yellow perch is slightly more than that reported by Kipling and Frost (1969) for northern pike and less than half that reported by Bagenal (1978) for marine fish.

Significant annual changes in fecundity are not unexpected in fish populations and would seem to be due to such factors as population density, temperature, food supply and other environmental effects (Bagenal op. cit.). Various authors have postulated that fecundity variations form a density-dependent population regulating mechanism; above average fecundity seems to be associated with low population numbers and vice versa (Bagenal 1978, 1973; Kipling and Frost 1969; Nickolsky 1963). Examination of annual fecundity estimates (adjusted to a common length) and indices of yellow perch abundance in Long Point Bay produced a strong negative relationship ($r = -0.903$, $P = 0.036$) between yellow perch stock size in year x and fecundity in year $x + 1$. While there were only six points over the study period where both sets of information were available for this analysis (Table 4.2.2-7), the result does suggest a circumstantial link between observed fecundity variations at Nanticoke and yellow perch stock size. Conversely, we found little relationship between fecundity and recruitment (based on YOY and yearling indices of abundance collected by the U.S. Fish and Wildlife Service). These findings corroborate statements by Bagenal (1973) who suggests that fish fecundity acts as a density dependent population regulating mechanism that tends to reduce wide fluctuations in recruitment and will not be associated with their cause.

The principal growth of Perca spp. ovaries occurs during the coolest seasons, when body growth ceases (Hokanson 1977). Our observations of yellow perch in Long Point Bay support this as maturity indices reached 8% by November but then rapidly increased to 17% by February. A minimum winter temperature of 10°C is near the upper limit for gonadal maturation in yellow perch and optimal conditions for maturation seems to occur when fish are exposed to 6° or less for 185 days from October 30 (Hokanson op. cit.). Clearly, prolonged residency of perch in heated water could adversely affect gonadal maturation. However, thermal plumes in other waters do not seem to attract yellow perch in the winter (Hokanson 1977, Neill and Magnuson 1974). Insufficient data are available concerning winter distribution of fish at Nanticoke, but available data suggests that perch do not concentrate at the NTGS plume in winter (Balesic, 1986). Hokanson (1977) suggests that a preference by yellow perch for low light intensity or ice-cover in winter may reinforce the low temperature requirements for gonadal maturation and guides the fish away from the influence of on-shore thermal plumes.

We have no evidence that the thermal plume influences gonadal maturation, although Ontario Hydro is presently finalizing a study conducted in 1984, which may shed more light on this issue. In the case of yellow perch, it would appear that the species does not congregrate near the plume during winter. Moreover, winter temperatures in the vicinity of the NTGS have remained well below the 10°C winter maximum at least until 1982 (Hokanson 1977); thus, the effect of the NTGS discharge on yellow perch recrudescence is expected to be negligible during the pre-1983 period. However, we are uncertain what the winter themal regime has been since tempering was reduced in 1983. Potential effects of Stelco's discharge on incubating ova presently are unknown, but Stelco is currently investigating this issue with reference to yellow perch eggs.

### 4.2.3 Summary

Information concerning fish spawning within the Nanticoke study area is insufficient. Although we have confirmed that several species do spawn within the general study area (or even within the discharge waters of industry), the extent of spawning here relative to other areas in Long Point Bay is not definitely established (but is expected to be of less importance than Inner Bay and the north shore of Long Point). That several key fish species (eg. smallmouth bass, rainbow smelt, white bass and possibly yellow perch) do spawn successfully within the immediate discharge waters of industry is significant, as these waters (while providing suitable stimuli for spawning) may subsequently produce unusual enviromental regimes for developing eggs and larvae. For instance, spawning within the NTGS discharge may subject deposited ova to unstable, and rapidly fluctuating temperatures. In addition, artificial increases in temperature may advance spawning and embryonic development. Griffiths (1976, 1978a) investigated possible effects of Ontario Hydro thermal discharges on yellow perch and rainbow smelt eggs, and suggested that these species would be the least likely of spring spawners to be adversely affected by thermal discharge. However, he predicted a 2 to 3 week advancement in smelt egg hatching, and substantial effects on the hatching success and developmental rate of yellow perch eggs, under thermal conditions imposed by heated water discharges.

The ecological significance of earlier spawning and accelerated embryonic development with respect to the size, condition, and ultimate survival of larvae within an elevated and fluctuating thermal environment is not fully understood. Early emergence of larvae and early dispersal of fry may be harmful as the necessary food may not be available (Langford 1983). However, this may only be an issue for highly mobile species where synchrony among widely different regions or environments is required (eg. sockeye salmon fry which hatch many miles upstream and immediately disperse downstream to ocean estuaries) (NAS 1973). In other instances, production of food organisms may advance in a similar way, with little disruption of food chains.

Wismer and Regier (1982) studied the effects of thermal discharge on smallmouth bass in Baie due Dore, Lake Huron. While earlier spawning and increased mortality on nests were predicted in response to elevated temperatures, the timing of spawning was unaffected (probably because spring water temperatures at the discharge and within the Baie were similar). No increase in nest mortality occurred; instead, first year growth was accelerated leading to increased overwinter survival. Increased overwinter survival is expected to lead to increased recruitment of adult size fish in the local sport fisheries.

A similar scenario may develop at Nanticoke for those species spawning in the immediate discharge area. Providing that the thermal regime does not increase mortality of developing ova, growth and abundance may increase in the area. Judging from our impression of sport fish catches at the NTGS, this situation may be in place already for smallmouth bass, as sport catches of this species appear to be increasing in the discharge area and are comprised of many young fish. Preliminary evidence from studies conducted by Ontario Hydro suggest that smallmouth bass spawning may be advanced by as much as two weeks in the NTGS discharge area (Balesic, 1986). The effects of this advanced spawning on survival over nests has not been investigated. This issue is discussed also in Section 3.2.4.

Spawning by several species in the NTGS discharge area is known to occur and the evidence suggests that conditions prior to 1984 were suitable for egg development. However, in June 1983, Ontario Hydro reduced tempering of discharge water, which poses a new set of environmental conditions (eg. reduced flow, higher absolute temperatures, greater $\Delta T$, and perhaps greater fluctuation in temperature) to spawners and developing eggs. The potential effects of tempering reduction on fish reproduction is presently under investigation by Ontario Hydro. The potential effects of discharge from Stelco on fish reproduction are unclear and must await the results of Stelco's biomonitoring program.

The only long term investigation relating to fish reproduction at Nanticoke has been the yearly estimates of yellow perch fecundity. While fecundity has varied over the study period, the variations are considered normal and may be more related to stock size than to direct environmental influences on ovaries. Yellow perch fecundity at Nanticoke is statistically similar to that in other areas of Long Point Bay and we have no evidence linking effects of industrialization to changes in yellow perch fecundity.

Table 4.2.1-1. Results of demersal sled tows and otter bottom trawls for rainbow smelt and yellow perch eggs at Nanticoke, 1982 - 1983.

| Sample Date (Y.M.D) | Area | Sample Gear | Eggs Present (P) or Absent (A) Smelt | Eggs Present (P) or Absent (A) Perch | Developmental Stage | Water Temp. (°C) |
|---|---|---|---|---|---|---|
| 1982.05.11 | NTGS Plume | sled | P | A | eyed | 11 |
| 1982.05.18 | NTGS Plume | sled | P | A | eyed | 17 |
| 1982.05.26 | NTGS Plume | sled | P | A | eyed | 16 |
| 1983.04.18 | Nanticoke Creek | sled | A | A |  | 9 |
|  | NTGS Plume | sled | P | A | eyed | 13 |
| 1983.04.19 | Centre Creek | sled | A | A |  | 9 |
|  | Stelco Dock | sled | A | A |  | 6 |
| 1983.04.22 | NTGS Plume | sled | P | A | eyed | 10 |
| 1983.04.25 | Oneida-Peacock | trawl |  | A |  | 9 |
|  | 1-mile reef | trawl |  | A |  | -- |
|  | Stelco Dock | trawl |  | A |  | 8 |
| 1983.04.26 | Oneida-Peacock | sled | A | A |  | 8 |
| 1983.04.29 | NTGS Plume | sled | P | A | eyed | 11 |
| 1983.05.04 | Centre Creek | trawl |  | A |  |  |
|  | Stelco Dock | trawl |  | A |  |  |
|  | Nanticoke Creek | trawl |  | A |  |  |
|  | NTGS Plume | trawl |  | A |  |  |
|  | NTGS Plume | sled | P | A | eyed | 11 |
| 1983.05.05 | 1-mile reef | sled | A | A | -- | 9 |
|  | Oneida-Peacock | sled | A | A | -- | 10 |
|  | NTGS Plume | sled | A | A | -- | 14 |

Table 4.2.1-2. Underwater surveillance of yellow perch and smallmouth bass (SMB) spawning in Nanticoke, 1983.

| Survey Date | Area | Dive No. | Dive Method[1] | Water Temp (°C) | Secchi Depth (m)[2] |  | Perch Eggs Present (P) or Absent (A) | No. Adult SMB |  | Predominate[3] Sediment Type | Inferred SMB Spawning Suitability | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  | Surface | Bottom |  | Guarding Nests | Not Guarding Nests |  |  |  |
| May 6 | 1-mile reef | (1) | T | 18 | 1.5 | 1.0 | A | 0 | 0 | B, R | fair | dense algae cover on boulder and rubble |
| May 11 | NTGS Plume | (2) | T | 12 | 2.0 | 1.5 | A | 0 | 0 | C, B | poor |  |
| May 11 | NTGS Plume | (3) | T | 12 | 2.5 | 1.5 | A | 0 | 0 | R, C | poor | dense algae cover on rubble |
| May 12 | NTGS Plume | (4) | T | 12 | 1.5 | 1.5 | A | 0 | 0 | B, BM | poor |  |
| May 12 | Centre Creek | (5) | T | 10 | 1.75 | 1.5 | A | 0 | 0 | B, S | fair |  |
| June 2 | Oneida-Peacock | (6) | T | 13 | 1.8 | 1.0 | A | 0 | 0 | R, BR | fair |  |
| June 2 | Oneida-Peacock | (7) | T | 10 |  |  | A | 0 | 0 | R, G | fair | dense algae cover on rubble |
| June 3 | NTGS Plume | (8) | T | 12 | 2.0 | 1.5 | A | 0 | 0 | CG, G | good | clean bottom, strong current |
| June 14 | NTGS Plume | (9) | F | 15 | 3.0 | 2.0 | A | 0 | 0 | R, B | fair | dense algae on boulders |
| June 14 | Oneida-Peacock | (10) | F | 15 | 3.0 | 1.5 | A | 0 | 0 | BR, G | good |  |
| June 14 | Oneida-Peacock | (11) | F | 17 | 2.1 | 2.0 | A | 0 | 0 | CG | fair |  |
| June 15 | Oneida-Peacock | (12) | F | 14 | 3.5 | 1.5 | A | 0 | 0 | S, M, B | poor |  |
| June 15 | Oneida-Peacock | (13) | F | 16 |  |  | A | 0 | 0 | R, C | poor |  |
| June 15 | Oneida-Peacock | (14) | F | 17 |  |  | A | 0 | 0 | S | poor |  |
| June 15 | 1-mile reef | (15) | F | 16 |  | 1.5 | A | 0 | >15 | B, R, G | good |  |
| June 16 | Centre Creek | (16) | F | 20 | 1.3 | 0.5 | A | 0 | 0 | S, BR | poor |  |
| June 16 | 1-mile reef | (17) | F | 17 | 2.5 | 1.5 | A | 0 | <10 | R, G | good |  |
| June 21 | NTGS Plume | (18) | F | 23 | 3.5 | 2.5 | A | 0 | <10 | B, S | poor |  |
| June 21 | Centre Creek | (19) | F | 19 |  |  | A | 0 | 3 | M, C | poor |  |
| June 21 | 1-mile reef | (20) | F | 19 | 3.5 | 2.0 | A | 0 | >20 | R, G, S | good |  |
| June 22 | NTGS Plume | (21) | F | 22 | 3.5 | 1.5 | A | 0 | 0 | B, M | poor |  |
| June 22 | 3-mile reef | (22) | F | 19 | 4.5 | 3.0 | A | 0 | >20 | R, B | poor | dense algae cover on rubble and boulders |
| June 22 | 1-mile reef | (23) | F | 21 | 4.0 | 1.0 | A | 0 | >20 | B, R, G | good |  |
| July 7 | 1-mile reef | (24) | F | 14 | [illegible] | 1.5 | A | 1 | 0 | B, H, G | good |  |
| July 11 | NTGS Plume | (25) | F | 18 | [illegible] | [illegible] | A | 1 | 3 | B, M | poor | Some [illegible] |

[1] T = [illegible] F = free dive

[2] [illegible]

[3] [illegible]

Table 4.2.1-3. Year class composition (%), mean lengths (mm) and mean weight of rainbow smelt taken at Nanticoke, Long Point Bay, Lake Erie, 1982 (Locations combined).[1]

| Year Class<br>Age | 1980<br>2 | 1979<br>3 | 1978<br>4 | 1977<br>5 | N |
|---|---|---|---|---|---|
| **% Composition** | | | | | |
| Males | 2.9 | 61.1 | 6.3 | 0.3 | 270 |
| Females | 0.3 | 25.1 | 3.4 | 0.8 | 113 |
| Combined | 3.2 | 86.2 | 9.7 | 1.1 | 383 |
| **Fork Length** | | | | | |
| Males | 145.8 | 154.4 | 159.4 | 184.0 | 273 |
| Females | 147.0 | 160.5 | 174.8 | 162.0 | 121 |
| Combined | 145.9 | 156.2 | 164.8 | 167.5 | 394 |
| **Total Length** | | | | | |
| Males | 158.9 | 167.3 | 172.7 | 199.0 | 273 |
| Females | 160.0 | 173.9 | 189.0 | 179.0 | 121 |
| Combined | 159.0 | 169.2 | 178.4 | 184.0 | 394 |
| **Weight** | | | | | |
| Males | 22.3 | 27.8 | 30.8 | 53.0 | 273 |
| Females | 21.0 | 30.9 | 40.6 | 54.0 | 121 |
| Combined | 22.2 | 28.7 | 34.2 | 53.8 | 394 |

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[1] Data from 32 mm mesh excluded to enable yearly comparisons

Table 4.2.1-4. Year class composition (%), mean lengths (mm), and mean weight (g) of rainbow smelt taken at Nanticoke, Long Point Bay, Lake Erie, 1983. (Sampling locations combined).

| Year Class<br>Age | 1982<br>1 | 1981<br>2 | 1980<br>3 | 1979<br>4 | 1978<br>5 | 1977<br>6 | 1976<br>7 | Combined<br>Ages | N |
|---|---|---|---|---|---|---|---|---|---|
| **% Compsition** | | | | | | | | | |
| Males | 0.1 | 67.7 | 6.8 | 1.8 | 0.4 | | | 76.9 | 1093 |
| Females | 0.1 | 18.6 | 2.3 | 1.6 | 0.3 | 0.1 | 0.1 | 23.1 | 329 |
| Combined | 0.2 | 86.4 | 9.1 | 3.4 | 0.7 | 0.1 | 0.1 | | 1422 |
| **Fork Length** | | | | | | | | | |
| Males | 117.5 | 129.7 | 134.0 | 163.9 | 174.7 | | | 131.2 | 1093 |
| Females | 132.0 | 132.9 | 144.5 | 173.5 | 182.8 | 180.5 | 171.0 | 138.0 | 329 |
| Combined | 122.3 | 130.4 | 136.7 | 168.4 | 177.9 | 180.5 | 171.0 | | 1485 |
| **Total Length** | | | | | | | | | |
| Males | 128.5 | 141.9 | 146.7 | 178.7 | 190.0 | | | 143.5 | 1093 |
| Females | 145.0 | 145.1 | 157.2 | 187.8 | 200.8 | 197.5 | 189.0 | 150.6 | 329 |
| Combined | 134.0 | 142.6 | 149.3 | 183.0 | 194.3 | 197.5 | 189.0 | | 1485 |
| **Weight** | | | | | | | | | |
| Males | 12.5 | 15.7 | 17.2 | 32.8 | 38.2 | | | 16.4 | 1093 |
| Females | 17.0 | 17.0 | 21.8 | 39.9 | 46.8 | 50.0 | 41.0 | 19.8 | 329 |
| Combined | 14.0 | 16.0 | 18.4 | 36.1 | 41.6 | 50.0 | 41.0 | | 1485 |

Table 4.2.1-5. Relative densities (No. eggs/sled tow) of rainbow smelt eggs in the NTGS plume, 1983.

| Survey Date | Transect | Approximate Distance from Discharge Outfall (m) | No. Tows | Mean No. eggs Per Tow | Developmental Stage | Water Temp. |
|---|---|---|---|---|---|---|
| April 22 | A | 0 - 200 | 3 | 372 | eyed | 13 |
| | B | 200 - 400 | 3 | 345 | eyed | 13 |
| | C | 400 - 600 | 3 | 628 | eyed | 8 |
| | D | 600 - 800 | 3 | 76 | eyed | 10 |
| April 29 | A | 0 - 200 | 3 | 1406 | eyed | 14 |
| | B | 200 - 400 | 3 | 133 | eyed | 10 |
| | C | 400 - 600 | 3 | 77 | eyed | 10 |
| | D | 600 - 800 | 3 | 45 | eyed | 9 |

Table 4.2.1-6. Observations of rainbow smelt spawning in Centre Creek, 1982 - 1983.

| Survey Date Y M D | Water Temp. (°C) | Observations |
|---|---|---|
| 1982.04.30 | 11 | - several hundred adult smelt in spawning condition were concentrated in a 60-m section immediately upstream of the discharge outfall<br>- ratio of males to females was 6.4:1<br>- all females were ripe, 75% were age 3 with mean FL = 148 mm; SD = 4.5<br>- males were ripe or partially spent, 31% were age 3 with mean FL = 144 mm; SD = 9.4 |
| 1982.05.02 | 10 | - smelt eggs on stream gravels |
| 1982.05.05 | 10 | - smelt eggs on stream gravels |
| 1982.05.12 | 7 | - smelt eggs on stream gravels |
| 1982.05.18 | 12 | - no smelt eggs on stream gravels |
| 1983.04.19 | 9 | - no evidence of smelt eggs on stream gravels<br>- concrete blocks placed in stream |
| 1983.04.20 | 7 | - newly deposited eggs (N>700) on one concrete block<br>- 3 blocks were removed prematurely by smelt netters |
| 1983.04.21 | 7 | - no smelt eggs on 4 of 5 blocks<br>- 1 block was removed prematurely by smelt netters<br>- 4 steel plates (egg collectors) installed in stream to replace blocks |
| 1983.04.22 | 9 | - no smelt eggs on steel plates |
| 1983.04.23 | 7-10 | - no smelt eggs on steel plates<br>- smelt eggs on stream gravels |
| 1983.04.25 | 7-10 | - newly deposited smelt eggs on steel plates (egg counts: 6, 7, 7) |
| 1983.04.26 | 11 | - newly deposited smelt eggs on steel plates (egg counts: 702, 52, 238, 411) |
| 1983.04.27 | 11 | - newly deposited smelt eggs on steel plates (egg counts: 0, 2, 8) |
| 1983.04.28 | 14 | - no smelt eggs on steel plates |
| 1983.04.29 | 13 | - no smelt eggs on steel plates |
| 1983.05.01 | 10 | - no smelt eggs on steel plates |
| 1983.05.02 | 15 | - no smelt eggs on steel plates |
| 1983.05.04 | 13 | - no smelt eggs on steel plates |
| 1983.05.05 | 14 | - no smelt eggs on steel plates |
| 1983.05.06 | 15 | - no smelt eggs on steel plates; 41 eggs of unidentified species on one steel plate |
| 1983.05.[illegible] | 13 | - no smelt eggs on steel plates |
| 1983.05.[illegible] | 15 | - no smelt eggs on steel plates |

Table 4.2.1-7. Comparison of larval fish densities (# larvae/tow) Nanticoke and Inner Bay, 1981.

| | | Inner Bay (1-m nets) | | Nanticoke (1-m nets) | | Centre Creek (½-m nets) | |
|---|---|---|---|---|---|---|---|
| Species | Period | Sum | Mean | Sum | Mean | Sum | Mean |
| Yellow Perch | Late May | 1399 | 139.9 | 196 | 3.6 | 4 | 0.2 |
| | Late June | 124 | 13.8 | 24 | 0.5 | 104 | 5.8 |
| Smelt | Late May | 3 | 0.3 | 1725 | 31.9 | 5 | 0.3 |
| | Late June | 35 | 3.9 | 4448 | 8.6 | 261 | 14.5 |
| Cyprinid | Late May | 0 | 0.0 | 0 | 0.0 | 11 | 0.6 |
| | Late June | 336 | 37.3 | 9 | 0.2 | 61 | 3.4 |
| Clupeid | Late May | 1 | 0.1 | 0 | 0.0 | 0 | 0.0 |
| | Late June | 3 | 0.3 | 0 | 0.0 | 0 | 0.0 |
| Number of Tows | Late May | 10 | | 54 | | 18 | |
| | Late June | 9 | | 51 | | 18 | |

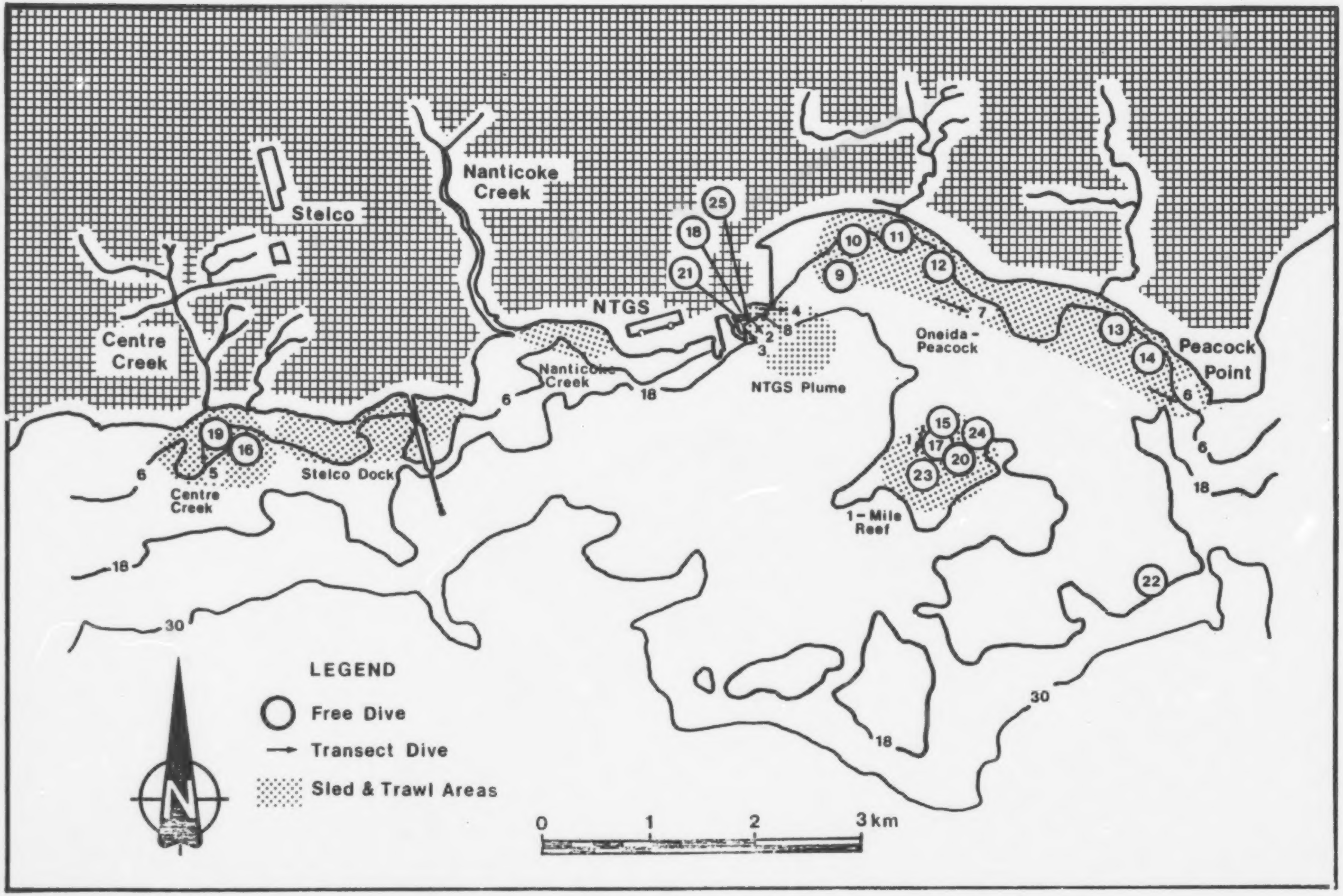

Stelco
Nanticoke Creek
Centre Creek
NTGS
25
18
21
4
2
8
3
NTGS Plume
9
10
11
12
7
Oneida - Peacock
13
14
Peacock Point
6
Nanticoke Creek
18
6
19
16
5
Centre Creek
Stelco Dock
15
17
24
20
23
1
1 - Mile Reef
22
18
30
6
18
30
18
LEGEND
Free Dive
Transect Dive
Sled & Trawl Areas
N
0
1
2
3 km

Figure 4.2.1-1. Nearshore areas of Nanticoke sampled for evidence of fish spawning with a demersal sled and otter trawl, and underwater surveillance, 1982 - 1983.

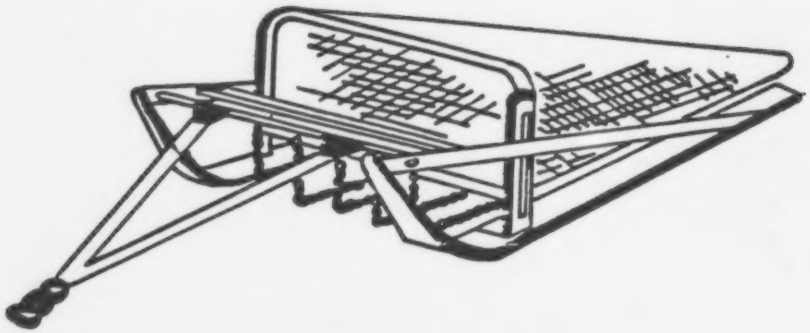


Figure 4.2.1-2. Demersal egg sampler for collecting rainbow smelt eggs in Nanticoke, 1982 - 1983.

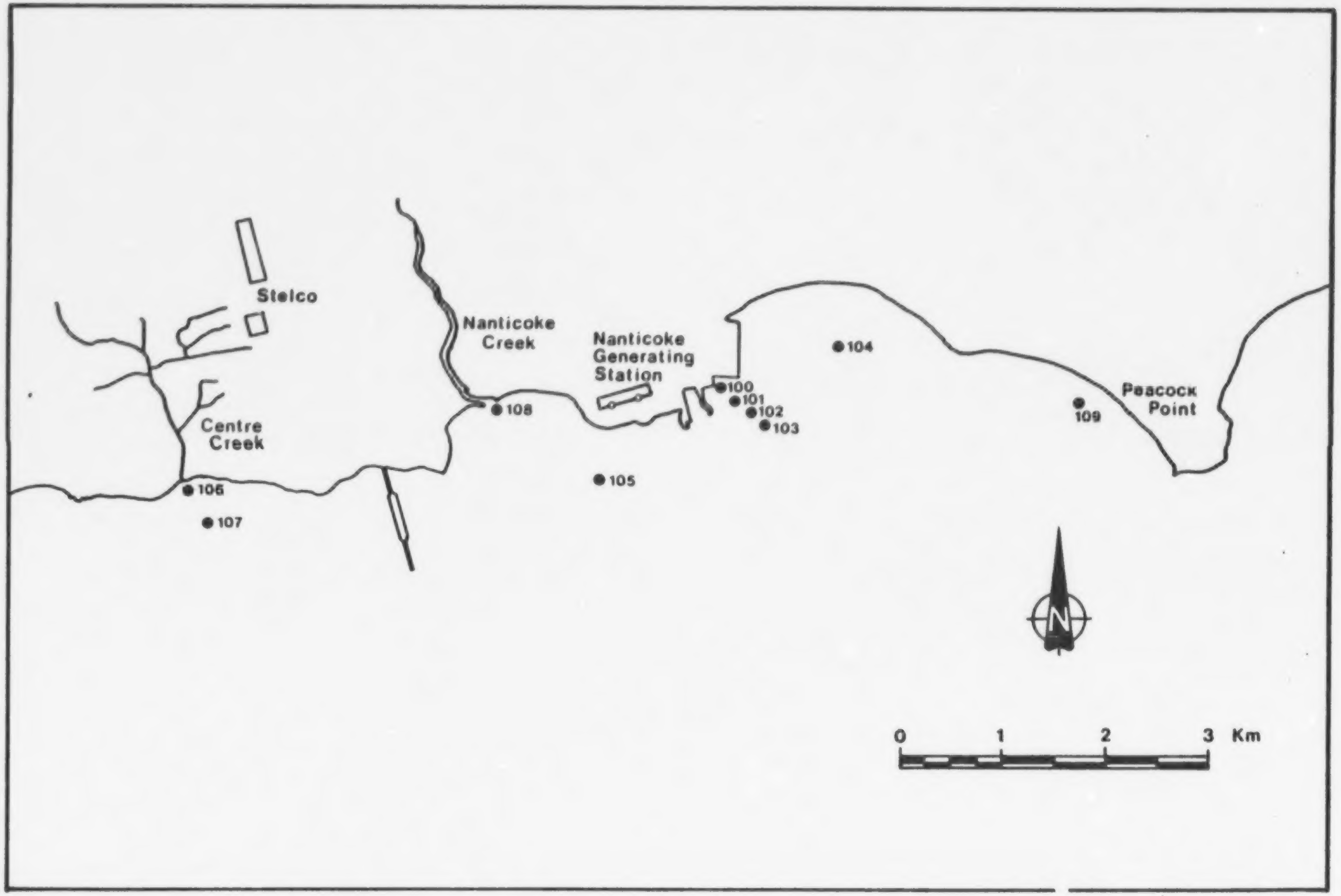
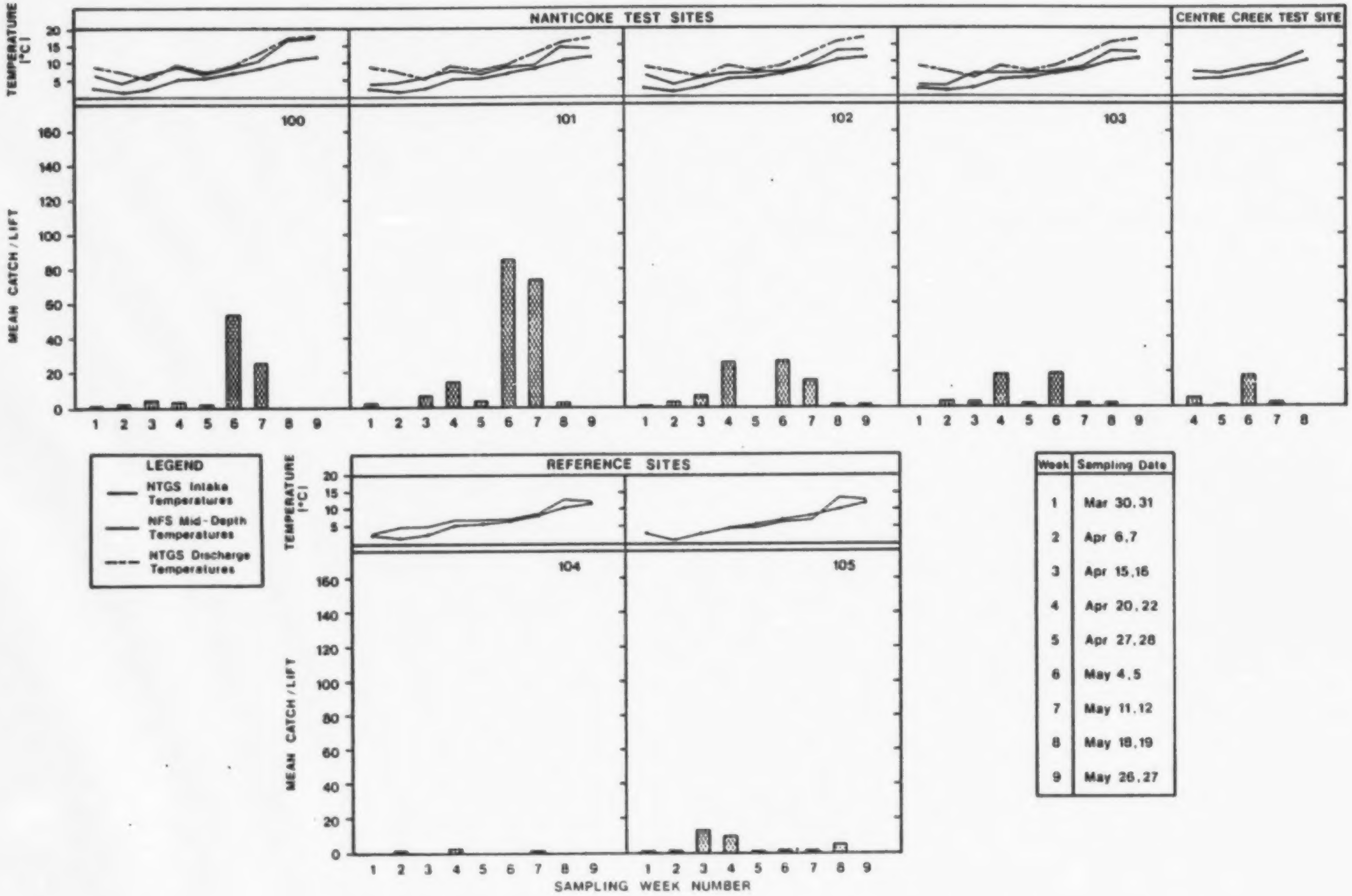

Stelco
Centre Creek
Nanticoke Creek
Nanticoke Generating Station
Peacock Point
106
107
108
105
100
101
102
103
104
109
N
0
1
2
3
Km

Figure 4.2.1-3. Gillnet sites for NTGS smelt spawning surveys conducted in 1982 and 1983, Nanticoke, Long Point Bay, Lake Erie.



| Week | Sampling Date |
|---|---|
| 1 | Mar 30,31 |
| 2 | Apr 6,7 |
| 3 | Apr 15,16 |
| 4 | Apr 20,22 |
| 5 | Apr 27,28 |
| 6 | May 4,5 |
| 7 | May 11,12 |
| 8 | May 18,19 |
| 9 | May 26,27 |

Figure 4.2.1-4. Mean catch per lift of rainbow smelt taken by gillnets at Nanticoke, Long Point Bay, Lake Erie, 1982.

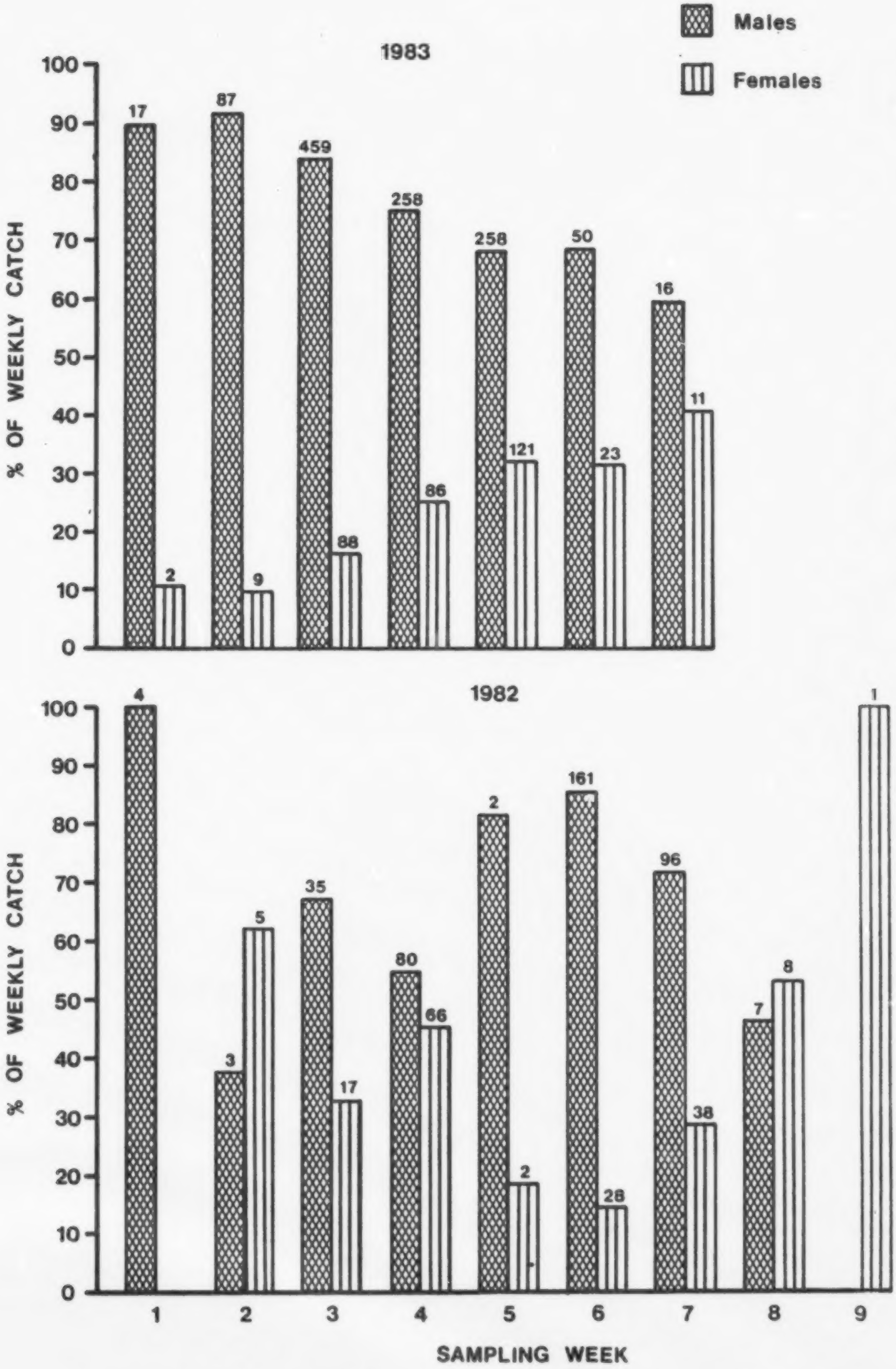


Figure 4.2.1-5. Weekly sex composition of rainbow smelt catches at Nanticoke, 1982 - 1983.

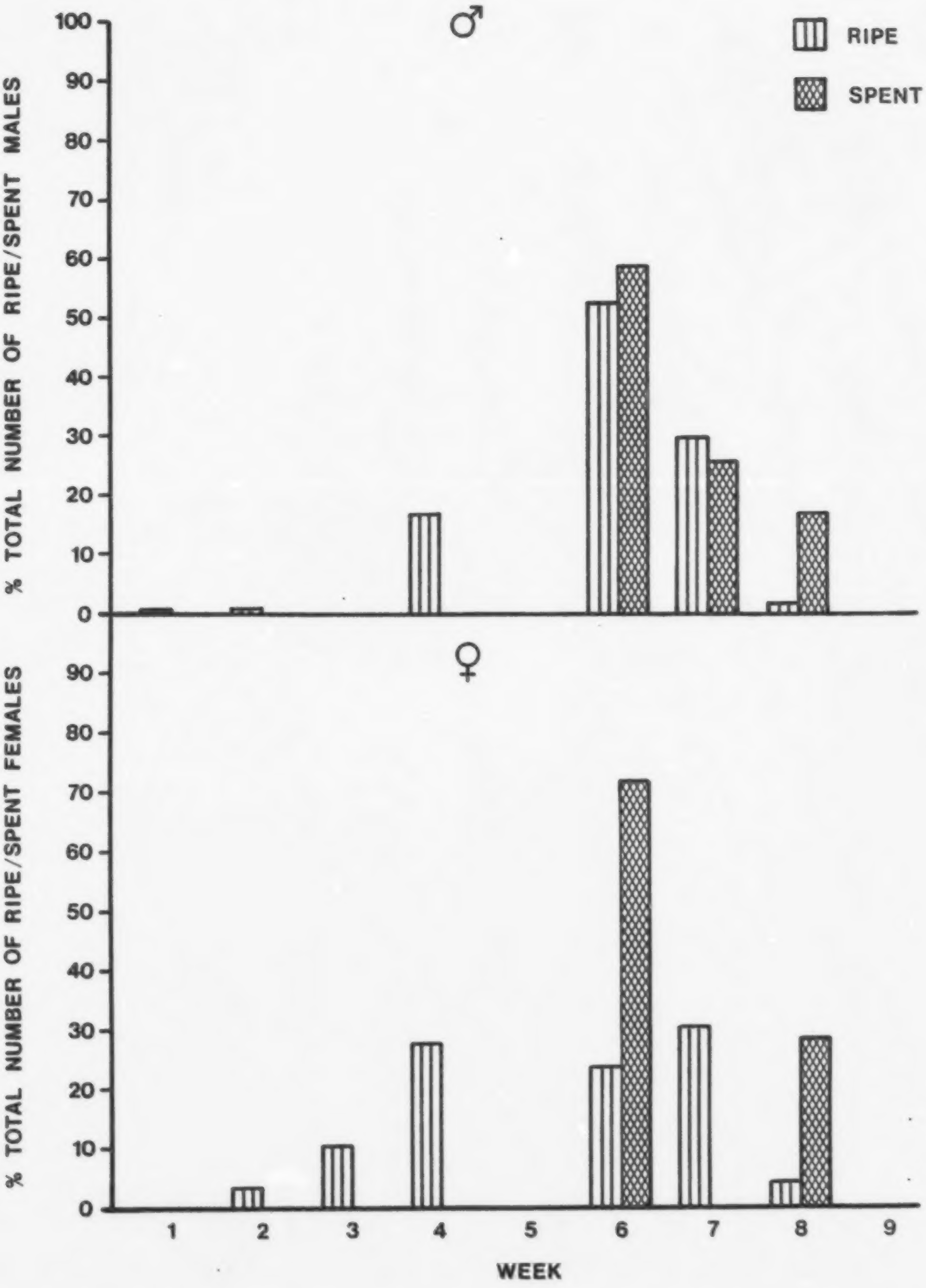
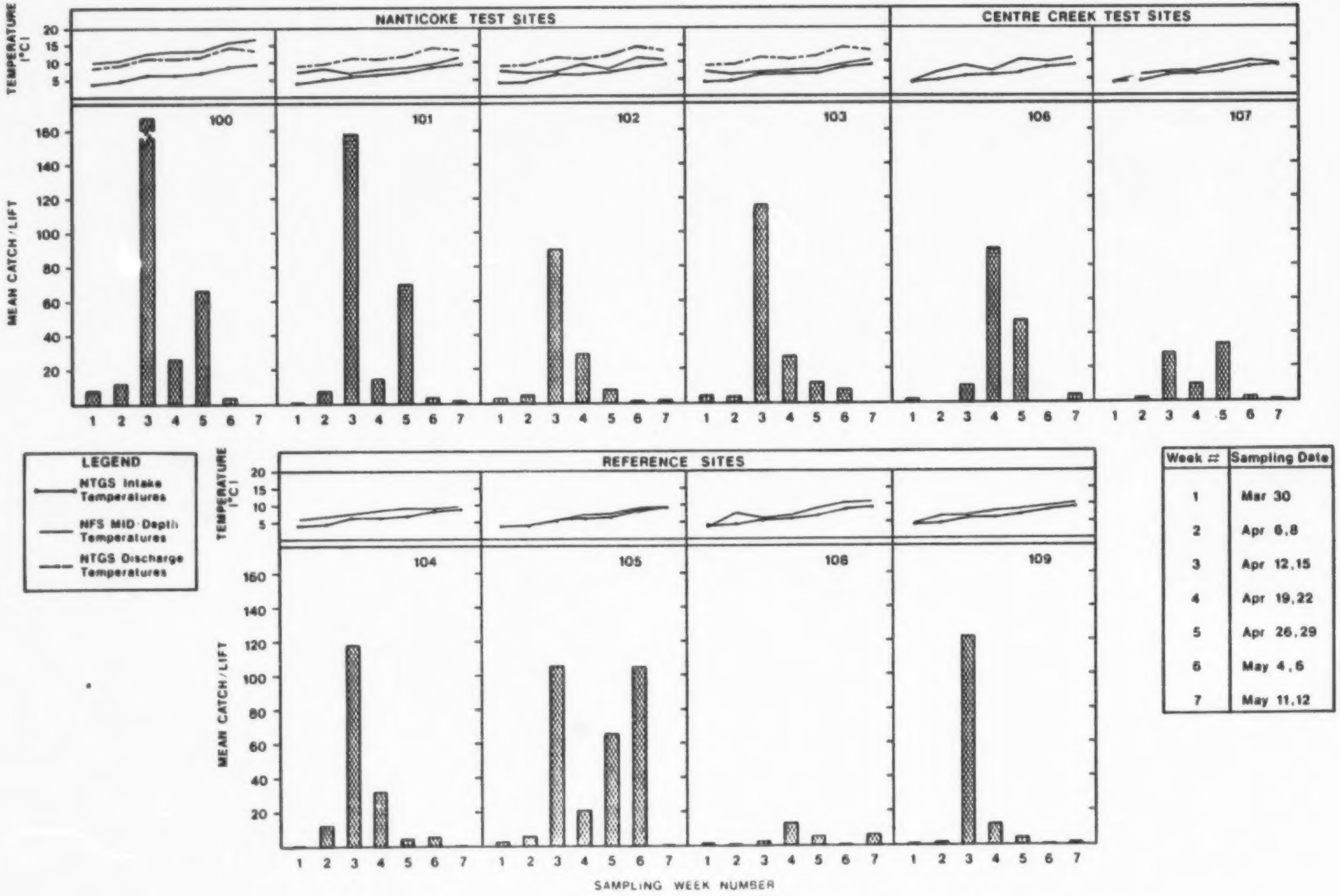


Figure 4.2.1-6. Weekly proportion of total number of ripe/spent smelt captured over the 1982 study period.



| Week # | Sampling Date |
|---|---|
| 1 | Mar 30 |
| 2 | Apr 6,8 |
| 3 | Apr 12,15 |
| 4 | Apr 19,22 |
| 5 | Apr 26,29 |
| 6 | May 4,6 |
| 7 | May 11,12 |

Figure 4.2.1-7. Mean catch per lift of rainbow smelt taken by gillnets at Nanticoke, Long Point Bay, Lake Erie, 1983.

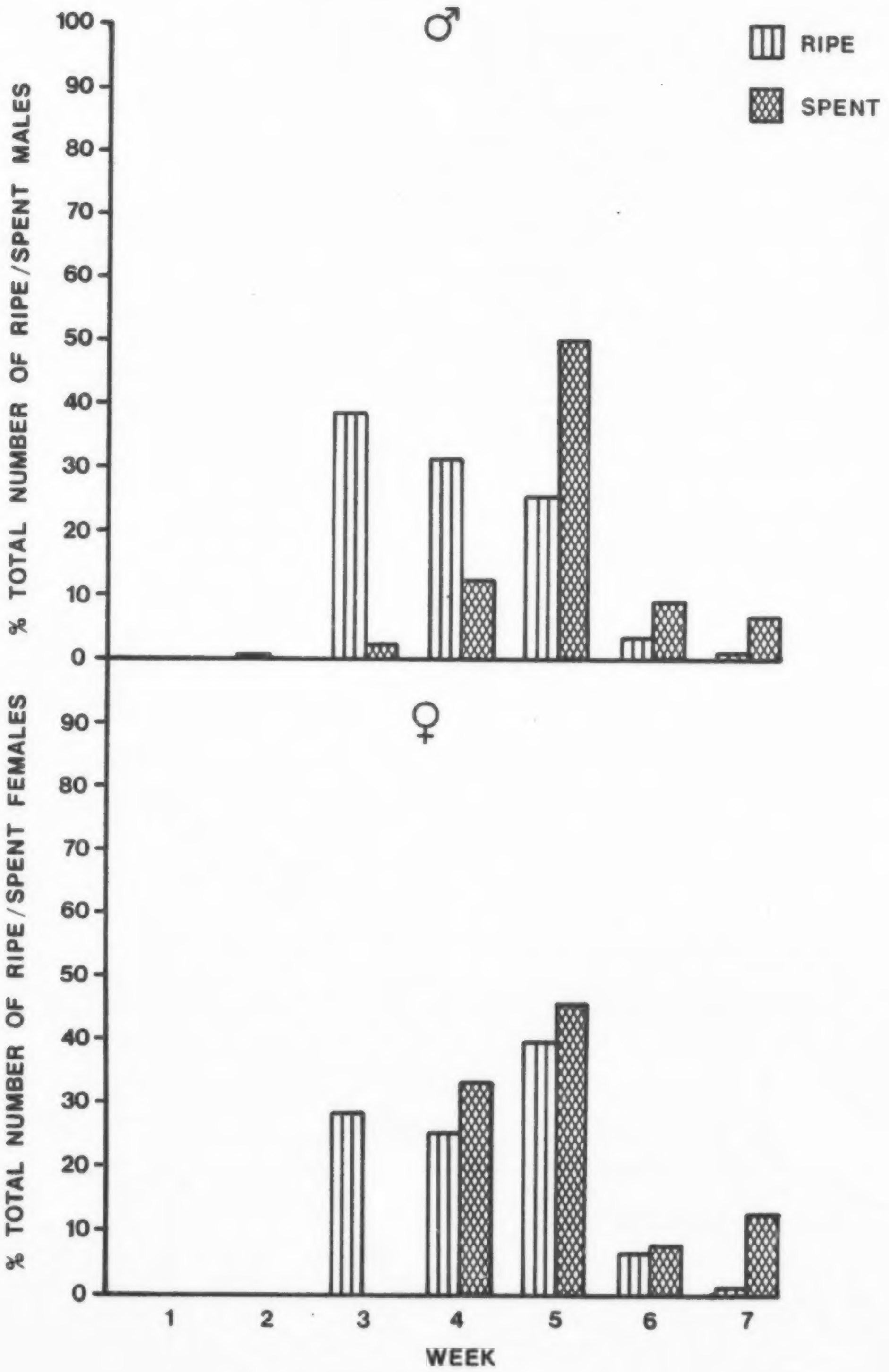


Figure 4.2.1-8. Weekly proportion of total number of ripe/spent smelt captured over the 1983 study period.

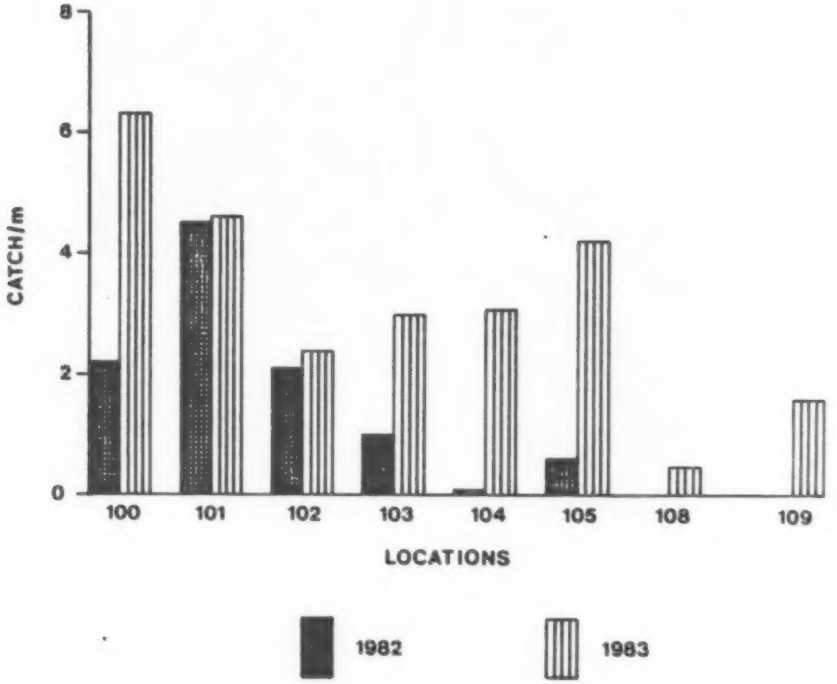


Figure 4.2.1-9. Catch per meter (pooled weeks) of rainbow smelt taken by gillnets set at Nanticoke (1982 - 1983) during the spawning season (smelt taken in 32 mm panel excluded from 1982 CUE).

Figure 4.2.1-10. Photograph of smelt eggs attached to a coal fragment collected from the NTGS plume, 1983.

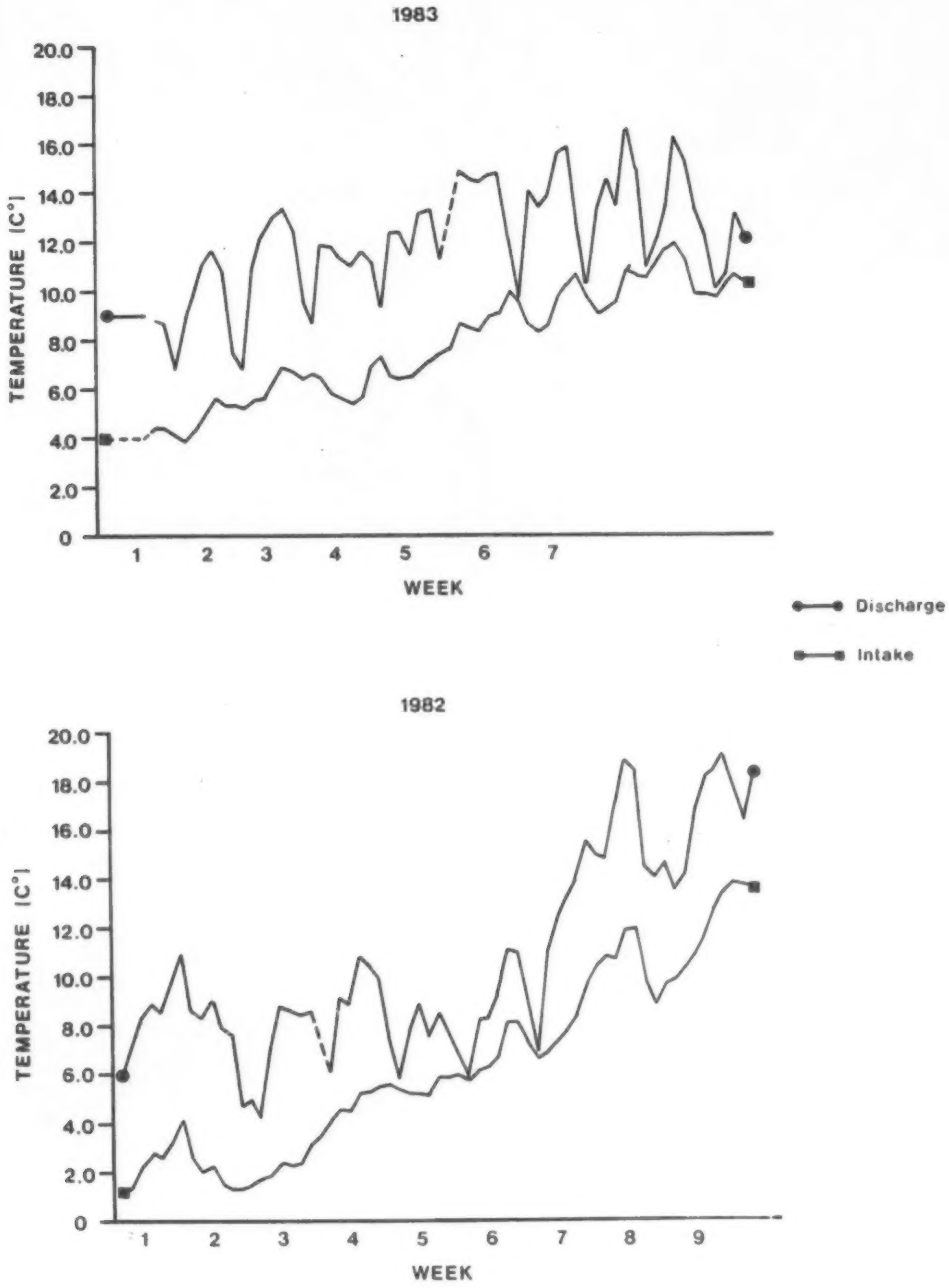


Figure 4.2.1-11. Daily mean intake and discharge temperatures at the NTGS during the 1982 and 1983 smelt spawning surveys.

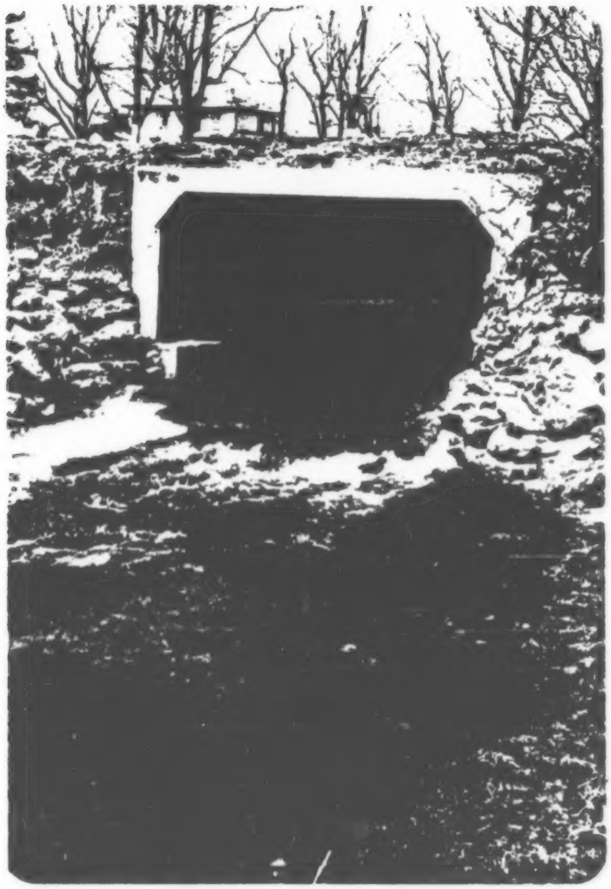


Figure 4.2.1-12. Photograph of rainbow smelt concentrating in Centre Creek (downstream of discharge from Stelco) May 1982.

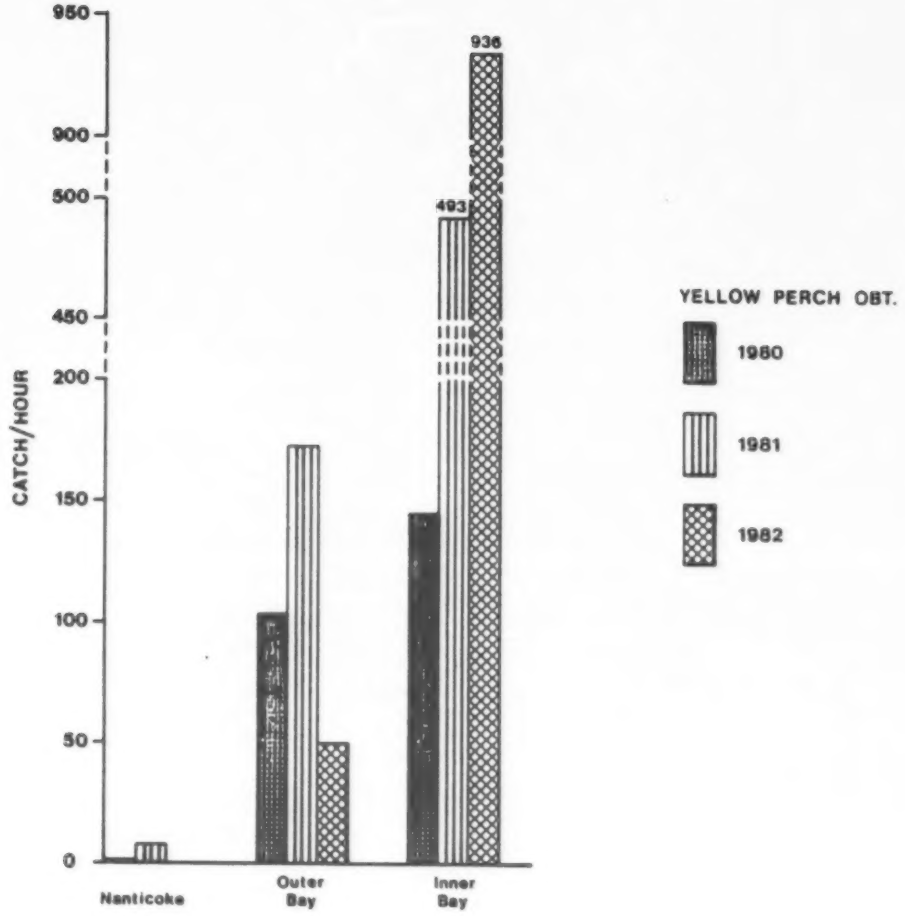


Figure 4.2.1-13. Catch per trawl hour of YOY yellow perch taken by otter trawls in Long Point Bay, Lake Erie (1980 - 1982).

Table 4.2.2-1. Regression (log-log) statistics of various fecundity relationships for female yellow perch, Long Point Bay, Lake Erie, 1974-1983.

| Independent Variable | Year | Intercept | Slope | $r^2$ | Standard Error of Estimate | N |
|---|---|---|---|---|---|---|
| Total Weight (g) | 1974 | 2.17521 | 1.00656 | 0.89 | 0.0840 | 66 |
| | 1975 | 1.87887 | 1.11194 | 0.83 | 0.0910 | 60 |
| | 1976 | 1.88105 | 1.10351 | 0.96 | 0.0686 | 87 |
| | 1977 | 1.91754 | 1.09976 | 0.90 | 0.0849 | 33 |
| | 1978 | 1.87681 | 1.12455 | 0.93 | 0.0878 | 33 |
| | 1981 | 1.98555 | 1.02709 | 0.88 | 0.1165 | 63 |
| | 1982 | 2.02725 | 1.05251 | 0.93 | 0.0927 | 165 |
| | 1983 | 1.97404 | 1.06771 | 0.95 | 0.0848 | 150 |
| Ovary Weight (g) | 1974 | 3.05801 | 0.85628 | 0.89 | 0.0830 | 66 |
| | 1975 | 3.03629 | 0.85672 | 0.70 | 0.1225 | 60 |
| | 1976 | 2.84136 | 0.93869 | 0.94 | 0.0806 | 86 |
| | 1977 | 3.16645 | 0.79794 | 0.90 | 0.0847 | 32 |
| | 1978 | 2.85463 | 0.95430 | 0.92 | 0.0926 | 33 |
| | 1981 | 2.88551 | 0.86680 | 0.89 | 0.1114 | 63 |
| | 1982 | 2.88976 | 0.92754 | 0.95 | 0.0806 | 166 |
| | 1983 | | 0.96798 | 0.95 | 0.0787 | 150 |
| Fork Length (mm) | 1974 | -3.02031 | 3.17960 | 0.86 | 0.0946 | 66 |
| | 1975 | -3.96714 | 3.55669 | 0.79 | 0.1015 | 60 |
| | 1976 | -4.29291 | 3.69872 | 0.94 | 0.0805 | 86 |
| | 1977 | -4.33420 | 3.72454 | 0.89 | 0.0889 | 32 |
| | 1978 | -4.59635 | 3.83437 | 0.90 | 0.1045 | 33 |
| | 1981 | -1.96218 | 2.66256 | 0.67 | 0.1907 | 63 |
| | 1982 | -4.01701 | 3.58775 | 0.91 | 0.1065 | 166 |
| | 1983 | -4.35173 | 3.72985 | 0.94 | 0.0903 | 150 |

Table 4.2.2-2. Analysis of covariance testing the effect of year on the fecundity of yellow perch captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1974-1983).[1,2]

| Source of Variation | df | Sum of Squares | Mean Square | F-value | P |
|---|---|---|---|---|---|
| Equality of Adjusted Means | 6 | 0.1224 | 0.0204 | 2.7427 | 0.0137 |
| Zero Slope | 1 | 11.8673 | 11.8673 | 1595.6992 | 0.0000 |
| Error | 223 | 1.6585 | 0.0074 | | |
| Equality of Slopes | 6 | 0.0552 | 0.0092 | 1.2458 | 0.2841 |
| Error | 217 | 1.6032 | 0.0074 | | |

[1] Based on a subsample of 33 fish/year (see text)

[2] 1981 data dropped from analysis due to poor fit of regression.

Table 4.2.2-3. Analysis of yearly trends in yellow perch fecundity at Nanticoke, Long Point Bay, Lake Erie (1974-1983). Lines join years that were not significantly different ($P > 0.05$, t-test matrix for adjusted group means in ANCOVA (see Table 4.2.2-2).[1]

| Rank | Year | Adjusted Group Mean Fecundity (Log 10) | | | |
|---|---|---|---|---|---|
| 1 | 1975 | 4.413 | | | │ |
| 2 | 1976 | 4.433 | | │ | │ |
| 3 | 1978 | 4.454 | │ | │ | |
| 4 | 1977 | 4.456 | │ | │ | |
| 5 | 1983 | 4.463 | │ | │ | |
| 6 | 1982 | 4.473 | │ | | |
| 7 | 1974 | 4.488 | │ | | |

[1] Based on a subsample of 33 fish/year.

Table 4.2.2-4. Expected fecundity (eggs per female) of a 228-mm yellow perch from Long Point Bay, together with regression statistics. Based on a subsample of 33 fish from each year, 1974-1983.

| | | 95% Confidence Interval | | | |
|---|---|---|---|---|---|
| Year | Expected Value | Lower | Upper | Intercept | Slope |
| 1974 | 30,171 | 28,631 | 31,794 | -4.10565 | 3.641 |
| 1975 | 25,398 | 23,686 | 27,233 | -4.24870 | 3.670 |
| 1976 | 26,590 | 25,026 | 28,253 | -4.16511 | 3.643 |
| 1977 | 27,992 | 26,052 | 30,078 | -4.37667 | 3.742 |
| 1978 | 27,843 | 25,556 | 30,332 | -4.59635 | 3.834 |
| 1982 | 28,852 | 26,465 | 31,455 | -2.97077 | 3.152 |
| 1983 | 28,416 | 26,464 | 30,512 | -4.93248 | 3.980 |

Table 4.2.2-5. Analysis of covariance testing the fecundity of yellow perch captured at Nanticoke vs the fecundity of yellow perch captured in the Inner Bay (1982-1983).

| Source of Variation | df | Sum of Squares | Mean Square | F-value | P |
|---|---|---|---|---|---|
| Equality of Adjusted Means | 1 | 0.0073 | 0.0073 | 0.9179 | 0.3393 |
| Zero Slope | 1 | 8.2636 | 8.2636 | 1045.5600 | 0.0000 |
| Error | 176 | 1.3910 | 0.0079 | | |
| Equality of Slopes | 1 | 0.0033 | 0.0033 | 0.4201 | 0.5177 |
| Error | 175 | 1.3877 | 0.0079 | | |

[1] T-test from ANCOVA for adjusted group means of Plume vs Control fish suggests no significant difference (P = 0.3395).

Table 4.2.2-6. Analysis of covariance testing the fecundity of yellow perch captured at the NTGS plume vs the fecundity of yellow perch captured at Nanticoke locations removed from the plume influence (1982-1983).

| Source of Variation | df | Sum of Squares | Mean Square | F-value | P |
|---|---|---|---|---|---|
| Equality of Adjusted means | 1 | 0.0065 | 0.0065 | 0.6566 | 0.4187 |
| Zero Slope | 1 | 11.5749 | 11.5749 | 1174.0900 | 0.0000 |
| Error | 207 | 2.0407 | 0.0099 | | |
| Equality of Slopes | 1 | 0.0097 | 0.0097 | 0.9864 | 0.3218 |
| Error | 206 | 2.0310 | 0.0099 | | |

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[1] T-test matrix from ANCOVA for adjusted group means of Plume vs. Control fish suggests no significant difference (p = 0.4189)

Table 4.2.2-7. Relationship between yellow perch abundance, fecundity and recruitment in Long Point Bay, Lake Erie.

| | | | Recruitment | |
|---|---|---|---|---|
| Year | Abundance[1] Index | Fecundity[2] | YOY[3] Index | Yearling[3] Index |
| 1974 | 37.0 | 30171 | 4.956 | 4.078 |
| 1975 | 37.1 | 25398 | 5.361 | 2.400 |
| 1976 | 26.6 | 26590 | 3.926 | 2.485 |
| 1977 | 29.4 | 27992 | 4.554 | 4.860 |
| 1978 | 26.6 | 27843 | 4.190 | 3.258 |
| 1981 | 22.2 | --- | 3.434 | 4.220 |
| 1982 | 20.9 | 28852 | 5.642 | 3.784 |
| 1983 | 15.6 | 28416 | 3.045 | 2.565 |

[1] Catch per unit effort (kg/km gill net) of yellow perch harvested by commercial gill net in Statistical District 4 (Cox 1981, Petzold personal communication).

[2] Expected fecundity of a 228-mm yellow perch.

[3] Derived from U.S. Fish & Wildlife Service index trawling in western Lake Erie (data are natural logarithms of catch per trawl hour).

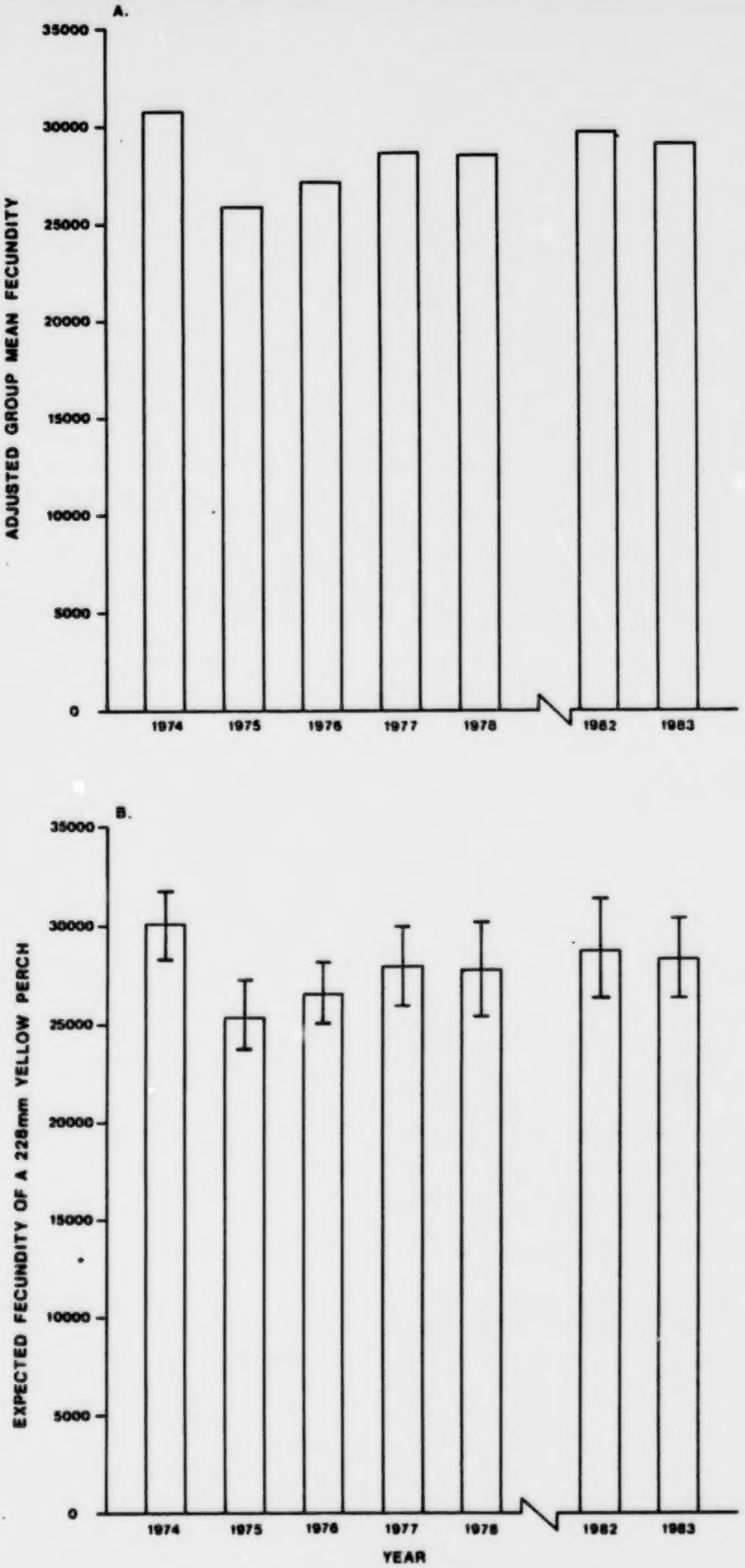

Figure 4.2.2-1. (A) Adjusted mean fecundities of yellow perch captured at Nanticoke, Long Point Bay, Lake Erie (1974-1983). Y-axis values derived from antilogs of $Log_{10}$ adjusted mean fecundities from ANCOVA (see text).

(B) Expected fecundity of a 228 mm yellow perch, Nanticoke, Long Point Bay, Lake Erie (1974-1983). Vertical lines are 95% confidence intervals.

## 4.3 AGE AND GROWTH

### Introduction

Growth rates of fish are among the most labile of biological characteristics, being influenced by food, space, exploitation and other environmental factors (Weatherly 1972, Gunning and La Nasa 1973, Kitchell *et al*. 1977, Spangler *et al*. 1977). Growth is one of the first population characteristics to respond to environmental change (Spangler *et al*. 1977) and, consequently, has been an important parameter in environmental assessment (Barwick and Lorenzen 1984; Gunning and La Nasa 1973; Kipling 1983; Ryan and Harvey 1977, 1980; Wrenn 1980).

We have monitored several indices of growth for yellow perch (heavily exploited), rock bass (lightly exploited), white bass (moderately exploited) and smallmouth bass (moderately exploited) since 1974 or earlier to enable detection of potential changes related to industrial activity at Nanticoke. As growth rates are among the most responsive of population characteristics to temperature (Kitchell *et al*. 1977, Spangler *et al*. 1977), changes in the thermal regime at Nanticoke due to heated water discharged by the NTGS may induce changes in growth rates. In practice, however (as we have noted in Section 3.2.5), many of the fish species range widely throughout Long Point Bay and Lake Erie in general; thus, changes detected are not easily related to industrial discharge.

## Methods

### A. Data Collection

Scale samples were collected annually from subsamples of our yellow perch, rock bass, smallmouth bass and white bass catches. Most of the samples were taken from the trapnet catches, although in the earlier years (pre-1978) additional samples from gillnet catches at Nanticoke were included. Fish from shoreline seine and outboard trawl samples in the Nanticoke area were used in some years to increase the number of small fish in the samples. From 1971-1975, an attempt was made to take a representative sample of the catch, but from 1976-1978 only 4 fish were sampled from each 20 mm size class (40-360 mm) per location per year, in an attempt to represent all size classes equally (Teleki _et_ _al_. 1977). This prevented calculation of age composition of the catches directly from aged fish - instead we were forced to estimate age composition for these years from age-length keys (see Section 3.2.1).

From 1980-1983 we again collected samples representative of the catch by randomly selecting a maximum of 40 fish of each species from each trapnet lift per location, over the entire field season. From 1981-1983 the samples from the first trapnet lift day of each week were killed and brought back to the laboratory where scale samples, sex, maturity and standard morphometric information were collected. On the second lift day during this period the fish samples were kept alive, scale samples removed, and length and weight data collected on board the vessel. These fish then were tagged and released (see Section

3.2.5). As no tagging was carried out in 1980, all samples from each trapnet lift were brought to the laboratory for processing.

In all sampling years at least fork length was determined for each fish from which scales were collected. Other information such as sex, maturity and weight was collected less frequently between 1971-1978. In the 1980-1983 period total length (mm), fork length (mm), and weight (g) were determined for all fish that were to be aged. Sex and maturity were collected from samples killed and returned to the laboratory; these data could not be determined for most tagged fish as dissection normally was required for sex determination.

In 1971 and 1972, 4-5 scales were taken from the left side of each fish above the lateral line (Kelso 1972, 1973a). After 1972, 5-10 scales were taken below the lateral line near the left pectoral fin. The scales were oven or air dried and impressions subsequently made on lead-acetate slides by means of a hand (1971-1978) or motor-driven (1980-1983) scale roller. Scale radius and the distance from focus to each annulus were measured (under magnification) from these impressions. Measurements were made to the nearest millimeter along the diagonal radius for all 4 species. From 1978 to 1980 scale measurements were made using a Trichiniscope microprojector. Subsequently, measurements were made by means of a microfiche reader. Calendar ages were assigned using the internationally accepted convention that January 1 is the designated birth date for all fish in the Northern Hemisphere. Therefore, a winter growth zone forming on the edge of scales was designated as an annulus on January 1, even if the zone was not complete (Jearld, 1983).

In reviewing age data prior to 1978, we found inconsistencies in assigning ages, particularly prior to 1976. This, combined with potential bias and errors in scale measurements due to distortions on the Trichinoscope microprojector lead us to re-age and re-measure all scales from the 1971-1978 collection period on the microfiche reader. All scale measurements were recorded as 80x magnification. For the earliest years (1971-1973) when sampling was radically different, only those samples originating from locations in the approximate area of our·standardized trapnet locations were used.

B. Data Summaries and Analyses

Full backcalculations were performed on samples from each collection year using a computer program originally written as a PL/I subroutine by Nickerson et al. (1980), which we modified and converted to Fortran (MacGregor and Burkholder 1983). This program utilized the standard Lee-Lea formula:

$$L_n = a + \frac{(L-a)}{S} S_n$$

where: $L_n$ = estimated fork length at the time of formation of the $n^{th}$ annulus

$S_n$ = magnified scaled measurement to the $n^{th}$ annulus

$L$ = fork length at time of capture

$S$ = magnified scale measurement to the edge of the scale (Scale Radius)

$a$ = intercept of the body-scale regression as previously determined from the sample ($L = a + bS$).

In some years, the correlation coefficients for the regressions of fork length on scale radius were lower than expected, possibly due to under-representation of small fish or changes in methods of scale collection (Grant 1981). Regression coefficients generally were lowest for rock bass, and small fish (younger age classes) were few in the samples of this species because of difficulties in capturing them at Nanticoke. When the fit is poor, least squares techniques usually underestimate the slope and overestimate the intercept (Griffiths 1978b). Carlander (1981, 1982) suggested the use of standard intercept values in order to reduce bias when making growth comparisons across locations or time. Because the intercept values in our data varied considerably from year to year (Table 4.3-1) we elected to follow this suggestion and standard intercepts recommended by Carlander (1982) for yellow perch (a = 30), rock bass (a = 25) and smallmouth bass (a = 35) were employed in our regressions. Inspection of these regressions (for years in which samples were represented by most size classes and coefficients were fairly good) revealed that these intercepts were reasonable for Long Point Bay stocks. As no standard intercept was recommended for white bass, a standard a = 30 was employed and was derived from samples collected in years in which samples were represented by younger age classes. Because few fish were sexed prior to 1980, all body-scale radius regressions were determined for pooled sexes, although we recognize that differences between sexes do occur in body-scale radius relationships (Chadwick 1975).

While full backcalculations were calculated, we suspected that problems relating to small sample size, size selective mortality and sampling bias could not be resolved in the data, particularly from the pre-1980 period where sample sizes were quite small. Consequently, in addition to the use of weighted mean backcalculated fork lengths, several other growth indices were used to examine trends and corroborate each other, including:

(1) Fork Length at Last Annulus

The fork length of each fish at the end of its last full year of life was calculated to compensate for differences in growth resulting from the different times of capture, with separations made according to year of capture.

(2) Empirical Fork Length at Capture (Spring)

The empirical age-specific fork lengths of fish captured between January 1 and June 30 was used to corroborate trends from length at last annulus estimates, assuming that little growth occurs during this period (annulus formation appeared to occur in mid-June (Grant, 1981) and it was assumed that somatic growth was negligible in that period).

(3) Last Increment of Growth in Length

Estimates of the last full year of growth in length were made for individual fish by subtracting the backcalculated fork length at its penultimate (second last) annulus from that of the last annulus ($l_i - l_{i-1}$).

(4) Population ($G_x$) and True ($\overline{G}$) Mean Growth Rates

Population growth rates ($G_x$) were computed by comparing the mean backcalculated fork lengths of the surviving fish at successive ages. Differences between the natural logarithms of these lengths were multiplied by the slope (b) of the functional length-weight regressions [$\log w = \log a + b (\log \ell)$] for each year's sample to give the instantaneous rates of growth in weight ($G_x$) (Ricker 1975).

Because size selective mortality was suspected, particularly for yellow perch, the true mean growth rate ($\overline{G}$) was estimated according to procedures recommended by Ricker (1975) using functional length-weight regressions.

While fork lengths were used in all growth computations, the following fork length (FL) vs total length (TL) regression equations enable conversion:

Smallmouth bass: $FL = 0.950(TL) + 1.570$ ($r = 0.998$)

White bass: $FL = 0.925(TL) + 0.218$ ($r = 0.998$)

Yellow perch: $FL = 0.973(TL) - 3.937$ $(r = 0.999)$

Rock bass: $FL = 0.978(TL) - 1.810$ $(r = 0.998)$

Statistical comparisons of empirical and backcalculated lengths at age, or last increments of growth across years, seasons, locations, sexes etc., were performed by ANOVA using Least Squares Means generated by the SAS GLM procedure (SAS Inst. Inc. 1982). No statistical tests were performed on weighted mean backcalculated fork lengths nor on instantaneous growth rates.

For many comparisons, samples were not sufficient in numbers and/or distribution in the earlier (pre-1978) years to enable valid tests. Consequently, comparisons among locations, sexes and seasons were confined to the 1980-1983 data where sample sizes were large and sample distributions were representative of the catch. Examinations for trends across years were made by calculating age-specific Spearman's Rank ($r_s$) and Kendall's tau B ($\tau$) correlation coefficients of backcalculated fork lengths and last increments of growth with year.

Age-specific weighted mean backcalculated fork lengths for each capture year, or individual year class, were plotted in various ways and it became apparent that growth of yellow perch and rock bass followed Ford-Walford plots of the von Bertalanffy growth formula rather well in some instances (Figures 4.3-1 and -2). This model was used to supplement our examinations of growth trends across years by fitting von Bertalanffy growth curves to weighted mean backcalculated fork lengths. The form of the von Bertalanffy equation was:

$$L_t = L_\infty [1-e^{-k[(t-t_0)]}]$$

where: $L_t$ = fork length (mm) at time t,
$L_\infty$ = fork length at which the growth rate is zero,
$K$ = the rate at which the growth curve approaches the asymptote, and
$t_0$ = theoretical age at which $L = 0$.

Ford-Walford plots of length increments $(L_{t+1}-L_t)$ against length $(L_t)$ were used to derive one set of von Bertalanffy growth parameters. These were then checked by plotting log $(L_\infty-L_t)$ against age, adjustments being made until the best fitting values of K and $L_\infty$ were obtained. The linear method of Bayley (1977) was used to provide alternative parameter estimates for the von Bertalanffy model. To facilitate comparisons, the von Bertalanffy model was reparameterized to produce the single parameter $\omega = K \cdot L_\infty$ after Gallucci and Quinn (1979).

The age structures of yellow perch and rock bass populations were determined by multiplying the total CUE at the Oneida trapnet location (see Section 3.2.1) by the proportion of the catch at each age. Indices of recruitment (year-class strength) were derived by summing the trapnet CUE's from ages III-VI for yellow perch and IV-VI for rock bass. Additional estimates of year-class strength for yellow perch were obtained from the results of cohort analyses for Statistical District 4 (Baker et al. 1985) either by summing the stock size estimates for each year class from ages II-VIII or by simply using the stock size estimate at age I. Similarly, indices of spawning stock abundance were calculated by summing the trapnet CUE's from ages III-VIII for yellow perch and for ages IV and older for rock bass. These indices were used to examine the relationships between growth (weighted mean backcalculated length at age) and year-class strengths or parental stock sizes of the two species by linear regression. The relationship between length at age of yellow perch and exploitation was examined by regressing weighted mean backcalculated length at age against total annual gillnet effort (km of smallmesh commercial gill net set in Statistical District 4; Cox 1982 and supplements).

## Results

### A. Fork Length-Diagonal Scale Radius and Length-Weight Relationships

The equations describing the fork length-scale radius relationships for each species are provided in Table 4.3.1. These regression equations include the intercepts (a-values) derived from the individual body-scale regressions on each year's sample. As noted earlier; however, standard intercepts for each species were substituted for the calculated a-values (see methods, this section) to reduce year-to-year bias in backcalculations. The large year-to-year variability in calculated a-values probably are due to difficulties in obtaining adequate samples with good representation of the youngest age groups (Carlander 1981).

The length-weight regressions for yellow perch and rock bass are provided in Table 4.3-2. Because few fish were sexed prior to 1980, the length-weight relationships for individual sexes were derived by first grouping the data into the three periods of industrialization, and these were the relationships that were used in all subsequent growth computations summarized by sex.

### B. Age Composition

Details concerning age composition of the trapnet samples are described in Section 3.2.1(vi). The results of these analyses clearly demonstrated that the age composition of our samples for growth analyses were influenced strongly by gear selectivity and by year-class strength (except in the 1976-1978 collection years when representative samples were not collected).

The trapnet catches of yellow perch were dominated consistently by age III fish, although ages II and/or IV were important when a particularly strong year class developed. The dominant age groups of rock bass catches varied from year to year depending on year class strength, but in general the important age groups ranged from ages III - VI. White bass catches in recent years have been comprised principally of age I fish, but age II fish were infrequently important also if the year class was strong. Smallmouth bass catches typically were dominated by age III, IV and/or V fish. (Tables 3.2.1-25, -26, and -29; Figures 3.2.1-23 to -26). Age and year-class compositions of trapnet catches as estimated by age-length keys or from aged subsamples (see Section 3.1-2.) are summarized for the four species in Tables 4.3-3 to -5.

### C. Sex

Yellow perch catches from the 1980-1983 collection years were predominately ($\overline{x}$ = 63.8%) female, whereas rock bass were predominately ($\overline{x}$ = 61.3%) male. These unbalanced sex ratios probably were due to manifestation of growth differences between the sexes (see also Section 3.2.1). Because few fish were sexed prior to 1980, comparisons of von Bertalanffy parameters across sexes were considered most valid when the data were grouped by period (see also 4.3(F)). Female yellow perch typically were significantly larger at age, exhibited larger growth increments, generally approached larger $L_\infty$ values and exhibited larger growth indices ($\omega$) than males within a given year class (Tables 4.3-6 to -8; Figures 4.3-3 and -4). Rock bass exhibited the reverse trend, males being significantly larger at age, approaching slightly larger $L_\infty$ values and larger growth indices ($\omega$) than did females in 1982 and 1983 (Tables 4.3-3 and -9; Figures 4.3-5 and -6).

No consistent differences in lengths at age were detected between sexes of white bass or smallmouth bass (Table 4.3-10), and the sex ratios of both species in the trapnet catches were more or less balanced (smallmouth bass: $\overline{x}$ = 53.6% female, white bass: $\overline{x}$ = 48.6% female).

The majority of yellow perch of both sexes captured in Nanticoke trap nets ($\geq$ 8-ft cribs) were mature by age II, but perch catches in Centre Creek trap nets (6-ft cribs) suggested that while all males were mature by age II, females were not all mature until age IV (Figure 4.3-7). On the other hand, female rock bass tended to mature earlier than males (all females were mature by age IV, whereas all males were not mature until age V) (Figure 4.3-8).

### D. Location

Differences in backcalculated lengths at age among the five standard trapnet locations were examined in Section 3.2.1(vi). While highly significant differences among locations were detected, the year by location interaction was highly significant and there was no consistent pattern within the years examined (Table 3.2.1-21, Figure 3.2.1-18).

Highly significant differences in lengths at age of yellow perch were detected between the plume (East and West Plume pooled) and control (East Brown's Pt., West Brown's Pt., Oneida and Peacock pooled) locations; however, differences in length increments between the two groups were not significant (Table 4.3-11). Length at age differences also were detected between plume and reference gillnet locations (see Section 3.2.2). In both instances (trapnet and gillnet samples), the lengths of yellow perch at age tended to be smaller at the plume locations (Figures 3.2.2-13 and 4.3-9), but some significant year by location interactions were detected in the trapnet samples, particularly for age III fish (Table 4.3-11).

No significant differences in growth increments or lengths of rock bass at age were detected between plume and control trapnet locations (Table 4.3-11, Figure 4.3-10). Small sample sizes of smallmouth bass and white bass precluded similar plume-control location comparisons for these species.

### E. Season

Within the most numerous age classes, season produced a significant effect on empirical fork lengths at capture, backcalculated lengths at last annulus and last increments of growth for both yellow perch and rock bass at age (Table 4.3-12). This effect was significant at age only on empirical fork lengths for smallmouth bass (Table 4.3-13).

Age-specific empirical fork lengths for rock bass typically increased from spring to fall, although there was little difference between spring and summer for age groups III and IV (Table 4.3-14, Figure 4.3-11). Backcalculated lengths of rock bass at age declined with season (at least from spring to summer) and this was notable particularly for ages III and IV fish.

Empirical fork lengths at capture for age II yellow perch typically increased from spring through fall, whereas this measurement exhibited little change between spring and summer for ages III and IV perch (but rose sharply from summer-fall). Backcalculated lengths of yellow perch at age declined steeply from spring to summer for ages II, III and IV fish and continued to decline through fall for age II perch. On the other hand, this measurement showed no change between summer and fall for age III fish and actually increased significantly from summer to fall for age IV perch (Table 4.3-14, Figure 4.3-11).

### F. Year and Period

Highly significant differences in age-specific empirical fork lengths, backcalculated fork lengths at last annulus and last increments of growth were detected across years and periods within the most numerous age classes of all four species examined (Tables 4.3-15 to -17). There was some indication of increasing lengths of rock bass and smallmouth bass at age across the study period. No trend in age I white bass lengths was observed (Figures 4.3-12 to -15). However, the backcalculated lengths at age of yellow perch appeared to decline across the study period, regardless of whether the data were grouped by year of capture (Figure 4.3-15) or year class (Figure 4.3-16).

Von Bertalanffy growth models produced realistic (ie. $L_\infty$ values comparable to largest fish in the population) parameter estimates for combined sexes of yellow perch in most periods, years and for most year classes (Tables 4.3-8, -18 and -19, Figures 4.3-4, -6, -17 and -18). However, when individual sexes were examined, unrealistic parameters frequently were generated for males, possibly due to low sample sizes of males (few fish were sexed in the early years and most of these were females). Consequently, year-to-year or year class comparisons of these parameters were considered most reliable for females or combined sexes (higher sample sizes). Only age groups 1-4 were used in year class comparisons of von Bertalanffy parameters for yellow perch. Parameter estimates generated by the method of Bayley (1977) usually were more reasonable than those of Ford-Walford plots, and were thus given more weight when considering trends. In general, there has been a slight tendency for K values of yellow perch to decline across years or year-classes while $L_\infty$ values tended to increase. The growth index ($\omega$) fluctuated widely among years or year-classes for yellow perch but again tended to decline slightly with time, particularly for females (Tables 4.3-18 and -19, Figure 4.3-19).

While von Bertalanffy growth parameters for rock bass were reasonable when the data were summarized by period or year of capture where age groups 1-10 could be used (Tables 4.3-8 and -20, Figures 4.3-20 and -21), those for individual year classes clearly were not (Table 4.3-21). When comparisons across rock bass year classes were made, only age groups 1-4 could be used and it appears that older age groups must be included to obtain realistic parameter estimates. No general trend across years or year classes in the growth index ($\omega$) were detected for rock bass but there was an indication of increasing $L_\infty$ and declining K parameters from the commissioning to operational period, particularly in the Bayley calculations (Table 4.3-20, Figure 4.3-22).

Nonparametric correlation analyses of age-specific backcalculated fork lengths and mean growth increments with year of capture revealed significant negative correlations of backcalculated lengths with year for ages II, III, IV and V yellow perch (Table 4.3-22). However, there appeared to be no consistent significant relationship between last increments of growth and year for yellow perch, despite some weakly positive relationships between this variable and length at last annulus (Table 4.3-23). On the other hand, true instantaneous growth rates ($\overline{G}$) of perch within age intervals II-III, III-IV and IV-V were significantly, and positively associated with year (eg. for females: $r = 0.743$, 0.613 and 0.651 respectively; $P < 0.05$).

The relationships between rock bass growth indices and year of capture were insignificant in most instances (Table 4.3-22); however, in all but one case the relationships were positive and significant positive correlations for ages V and VII were detected. Instantaneous growth ($\overline{G}$) was positively related to year for age intervals III-IV, IV-V, V-VI, and VI-VII but was significant only for age interval IV-V ($r = 0.811$, $P < 0.01$). Correlations between year of capture and growth indices for white bass and smallmouth bass were weak in general, although there was an indication of positive trends for smallmouth bass. The sample sizes for these latter two species were small and scattered so it is unlikely that any significant trend could be detected by correlation analyses.

While lengths at age of yellow perch declined across the three study periods, instantaneous growth rates and length increments did not exhibit much change (in fact, slight increases within the younger age groups were observed) (Figure 4.3-23). Lengths at age and instantaneous growth rates for rock bass increased slightly from the commissioning to operational period (Figure 4.3-23).

Weighted mean backcalculated lengths at age for rock bass were significantly, but negatively correlated with year class strengths, whereas no significant relationships between lengths at age nor instantaneous growth rates ($\overline{G}$) and year class strengths of yellow perch were detected (Tables 4.3-24 and -25). However, weighted mean lengths at age of yellow perch were significantly, but negatively correlated with total annual gillnet effort (Table 4.3-26). There were no significant relationships between annual stock size estimates and lengths at age for both species (Tables 4.3-27 and -28, $P>0.05$ for all ages of both species).

## Discussion

For comparative purposes, calculated lengths at annulus for yellow perch, rock bass, smallmouth bass and white bass in other North American waters were drawn from the literature and converted to fork lengths where necessary (Tables 4.3-29 to -32). In all instances, growth (calculated lengths at age) of these species at Nanticoke fell within the reported range and ranked among the highest. Growth of both yellow perch and rock bass at Nanticoke appeared to follow the von Bertalanffy model, and the parameters generated for yellow perch were comparable to those few studies reporting this information for yellow or European perch (Perca fluviatilis) in other waters (Craig 1974, 1980; Goldspink and Goodwin 1979; Thorpe 1977a). However, $L_\infty$ values at Nanticoke generally were among the highest reported.

With the exception of yellow perch, there is little published information concerning the comparative growth rates of these species in other waters of Lake Erie. However, Petzold and Paine (1978) have shown that while the lengths of yellow perch at age in Outer Long Point Bay are smaller than in the Central Basin, they are comparable on this basis to perch in the Western Basin. Hayward and Margraf (1983) have shown that perch growth in the Central Basin is clearly faster than that in the Western Basin for all size groups. That perch within the mesotrophic Central Basin should grow faster is not unexpected in view of the findings of Entz (1977) who showed that mesotrophic waters provide optimal conditions for growth, production and reproduction of yellow perch. Slower growth of perch within the more oligotrophic Eastern Basin may be the result of colder water temperatures, while slower growth in the eutrophic Western Basin may be the result of more intense inter-/intra-specific competition (density-dependent growth).

In addition, Petzold and Paine (1978), Grant (1981) and Martin (1983) have shown that Inner Bay perch are slower growing and in poorer condition that those in the Outer Bay. This observation has been attributed to more intense competition for food in the Inner Bay (Petzold and Paine 1978) and to high summer water temperatures here that appear to exceed the optimum for yellow perch growth (Grant 1981).

Observed sexual differences in growth for the species examined in our study corroborate the findings of other investigations. Generally all indices of growth we measured for yellow perch suggested faster growth by females. Similar findings for both yellow and European perch in other waters have been reported by Craig (1974, 1980), Henderson (1985), LeCren (1958), Mann (1978), McCormack (1965), Ryan and Harvey (1980) and Thorpe (1977b). The tendency for male rock bass to grow faster than females at Nanticoke has been reported for the species in several other waters in Michigan, Wisconsin and Minnesota, and it has been suggested that superior late season growth by males accounts for this (Carlander 1977 and references therein). There appears to be no report of sexual differences in growth by smallmouth bass (Carlander 1977) and we found no obvious differences at Nanticoke. Information concerning comparative growth among sexes of white bass is scant but, similar to our study, Van Oosten (1942) found very little sexual difference in growth for the species in Lake Erie.

Rosa Lee's phenomenon was evident in backcalculated lengths of yellow perch, rock bass and smallmouth bass, but not for white bass (Tables 4.3-33 to -36). For those species where the effect was notable, it was surprisingly most pronounced in the rock bass data and least pronounced in yellow perch data despite the strong selective mortality imposed on the yellow perch population by the commercial gillnet fishery (which targets on perch), and the lack of any significant fishing mortality (sport or commercial) imposed on rock bass. The severe selective mortality imposed on the perch population is most clearly demonstrated when true (individual) growth rates ($\overline{G}$) are compared to population growth rates ($G_x$) (Table 4.3-37), and it is noted that within the age intervals most heavily harvested by commercial gillnet (ages II-IV), $G_x$ is almost invariably less than $\overline{G}$. Of equal importance is the strong reversal of this trend (usually at age interval IV-V for females and V-VI for males) where population growth increases sharply and exceeds individual growth.

The most likely explanation for this observation, which occurs consistently in the data from each collection year (eg. see Table 4.3-37), is related to commercial fishing. The commercial gillnet fishery targets on yellow perch by fishing almost exclusively 2-1/4 inch square mesh gill net, and the resultant harvest is comprised principally of ages II-IV fish. Within these age intervals the faster growing perch are harvested first, leaving behind the slower growing ones. This has been demonstrated in our data even across the open water seasons within a single fishing year; Figure 4.3-11 clearly shows that backcalculated fork lengths of those aged II and III perch captured in the fall were significantly smaller at age than were those captured in spring, suggesting that as the seasons progress, proportionately more slower growing fish are vulnerable and available in fall than in the spring, apparently because the faster growing individuals are cropped earlier in the fishing year.

As yellow perch are most vulnerable to commercial gill net at age IV (Baker et al. 1985), this process of selectivity will work in reverse for those fish older than age IV. The slower growing age V fish which managed to escape the fishery are still vulnerable to the gear, thus proportionately more slower growing age V fish will be harvested, leaving behind more faster growing individuals at this age. Therefore, within a given year the population is comprised of more slower growing aged II-IV individuals left behind by the commercial fishery, and the few remaining faster growing individuals (ages V and older) that escaped the fishery. Support for this hypothesis lies in the fact that no relationship existed between the lengths of the faster growing age V female perch and gillnet effort, whereas a significant negative relationship still persisted at this age for the more slowly growing males (Table 4.3-26). Indeed, when sufficient data was available, $G_x$ for males generally did not exceed $\overline{G}$ substantialy until age interval V-VI, which is one age interval beyond where this occurred for females (Table 4.3-37). The apparent large jump in population growth ($G_x$) between, for example, ages IV and V female perch would appear to be a simple artifact resulting from the subtraction of slower growing age IV fish from faster growing age V fish. This artificial population structure imposed by the commercial fishery could explain why Rosa Lee's phenomenon was not clearly evident in the perch data. The existence of Rosa Lee's phenomenon for the other species probably is a function of gear selectivity where only the faster growing individuals of the younger age classes are vulnerable to the trap nets; this, combined with some selective mortality of the older aged fish would produce the resultant declining backcalculated lengths with age.

The clearest trend in the growth indices we monitored for the four species has been a decline in age-specific empirical (spring) and backcalculated lengths of yellow perch across the study period (particularly for age groups up to age IV) (Figures 4.3-15 and -24). However, neither true instantaneous growth rates ($\overline{G}$) within these intervals nor growth increments have declined. The decline in lengths of yellow perch at age has been shown to be significantly correlated with increasing gillnet effort in the bay (Table 4.3-26) and is thus a reflection of the process described above. As gillnet effort increased, more faster growing fish are harvested and proportionately more slower growing individuals would be left behind, producing an apparent decline in length at age for the vulnerable age groups. Similar tendencies in perch size are found in independent data collected annually in all three basins of Lake Erie from index gillnet programs conducted by the OMNR research unit stationed in Wheatley, Ontario. Examinations of mean age-specific total lengths of perch captured during the spring in this gear reveals a similar declining trend in length at age over the same time frame (Figure 4.3-25). As commercial gillnet effort has expanded lakewide in recent years (Cox 1982 and supplements) in conjunction with an apparent reduction in mesh size (Baker et al. 1985), the same explanation probably holds in the remaining basins, particularly since gillnet effort is much more intense in the Central and Western Basins than it is in Long Point Bay. Thus, lengths at age in this situation are not good indicators of growth and it is likely that this effect has lead to similar confusion in von Bertalanffy growth parameters (K and $\omega$) for perch.

The density of the yellow perch stock in Long Point Bay apparently has declined over the study period (Table 4.3-27), and (ignoring trends in length at age data) there is some evidence that perch growth has increased slightly over the same period (mean growth increments and particularly $\overline{G}$ have increased since 1971, Table 4.3-38, Figure 4.3-26). However, the relationships between these two growth indices and year-class strength or stock size were not significant ($P>0.05$).

Density-dependent growth responses by both yellow and European perch (Perca fluviatilis) have been demonstrated in other waters (Henderson 1985, Le Cren 1958, Craig et al. 1979, Rask 1983) but it is probable that any such response in Lake Erie has been obscurred by the confounding effects of the gillnet fishery.

Although fewer years of data are available for rock bass, the more typical inverse relationship between growth (size at age) and year class strength was exhibited (Table 4.3-24). However, the relationship between stock size and growth was not significant. The decline in size when year class strengths were high suggests that competition for a limited food supply increased (Healey 1980) and that this competition takes place mostly between fish of the same year class (Henderson 1985). This would appear to be a function of size-selective feeding behaviour which has been demonstrated for yellow perch in our studies (see Section 4.2) and for rock bass by Keast (1970) and Keast and Webb (1966). The apparent slight upward trend in growth by this species across the study period (Figures 4.3-24, -26 and -27) may not be due exclusively to fluctuations in year-class strengths, and the effects of potential enhancements in such factors as temperature and food supply at Nanticoke may also have been important in stimulating growth. As rock bass tend to remain in the study area for much of the growing season after spawning (see Section 3.2.5) such growth stimulation is not inconceivable.

Similarly, there has been a slight tendency for the size of older smallmouth bass at age to increase across the study period (Figures

4.3-12 and -28), and a corresponding tendency for true growth rates ($\overline{G}$) to increase was observed in the data (Table 4.3-38, Figure 4.3-26). Because of low annual trapnet catches, the CUE's for this species are not considered to be good indicators of year-to-year abundance; hence, no attempt was made to relate growth indices to stock size or year-class strengths. The sample sizes of smallmouth bass used for growth analyses were small each year and the variability was quite high so no clear statement can be made regarding trends in growth of this species at Nanticoke. However, the results of recent creel surveys at the NTGS discharge area suggests a tendency for smallmouth bass to concentrate in the discharge area in spring and fall (see Section 3.2.4); since a large proportion of our smallmouth bass samples in recent years have come from the discharge area it is possible that growth stimulation has arisen from enhanced environmental conditions in the plume area (i.e. elevated temperatures and more abundant forage). Shuter _et_ _al_. (1985) made similar observations at the Bruce Nuclear G.S. where smallmouth bass of all ages tended to concentrate in the discharge area and an increase in growth of all age groups was observed.

Small sample sizes and the high proportion of only one age group (age I) in our white bass samples precluded any detailed analyses of white bass growth at Nanticoke, although the age I fish did not exhibit any upward or downward trend in lengths at age across the study period.

The growth analyses of fish species at Nanticoke have been severely hampered by small sample sizes in the early years, by the widespread movements of fish within Long Point Bay (Section 3.2.5), and by the confounding effects of the commercial gillnet fishery on the structure of the perch population. For these reasons no firm conclusions can be made regarding the effects of industry (or lack of it) on the growth of most species. If it is accepted that the declining trends in yellow perch at age are not true indicators of growth, and that the apparent upward trend in $\overline{G}$ for this species is real, then the general tendency for all species but white bass has been towards a slight increase in growth. While it is conceivable that growth of rock bass and smallmouth bass has been stimulated by enhanced environmental regimes at Nanticoke (eg. discharge of heated water) because of their tendency to remain in the Nanticoke area for much of the growing season, it is less likely in the case of perch. If perch growth rates have increased it would seem improbable that it is related to industrial discharge because of the tendency for this species to range throughout the bay, and the lack of evidence that individual perch remain in the heated water area for any substantial period of time (see Section 3.2.5).

There is considerable, but conflicting evidence regarding the importance of temperature in influencing the growth of both yellow and European perch (Coble 1966, Henderson 1985, Le Cren 1958), and the influence of population size apparently is at least as important as temperature (Henderson 1985). Hayward and Margraf (1983) suggest that density-dependent mechanisms play a far more direct role in growth rate differentiation than do temperatures. As temperatures at Nanticoke near the NTGS outfall have increased over the study period, whereas population size apparently has decreased in Long Point Bay over the same period, these two factors may be operating in opposition to each other with respect to perch growth. However, in view of the relatively small area influenced by the NTGS discharge and the wide ranging nature of perch, the influence of elevated temperatures at the outfall on growth of the total population would be small and likely not detectable in our data.

It is difficult to explain why the age-specific lengths of yellow perch captured in the vicinity of the NTGS discharge channel were slightly, but significantly smaller than those captured at reference locations. Because this tendency was observed in two independent series of data (trapnet and gillnet catches, see also Section 3.2.2), it is probable that the observation is real, but whether, or not this is directly related to true changes in growth is difficult to establish, particularly since the growth increments were not substantially different between locations. Poorer growth rates in a heated water outfall are theoretically possible as Neill and Magnuson (1974) have shown that food-deficient outfall areas might be expected to attract fishes that prefer high temperatures, despite the fact that poorer conditions for growth would prevail. However, as perch tend to avoid the warm areas of outfalls and range widely in Long Point Bay, it is more probable that the observation is related to size-differential movements and distribution of the fish (Neill and Magnuson 1974).

Clearly, we cannot conclude much concerning the direct influence of industrialization on the growth of fish at Nanticoke. While there is some tantalizing evidence that some growth stimulation has occurred, it is far from conclusive what the stimulus was. The overriding factor is that while changes have been observed, the magnitudes were not large and not negative.

Probably the most important influence we have detected is the selective action of the commercial fishing industry on the size structure of the perch population. This issue bears further investigation in some other forum, particularly with respect to the genetic consequences of the selective harvest on growth rates. The usual expectation for exploited fish populations is increased growth as a density-dependent response (OMNR 1983). However, Favro _et al_. (1979) have pointed out that size-selective fishing poses an unnatural selection process in which the faster growing fish are preferentially killed at an earlier age, possibly even before sexual maturity is reached. Models generated by these authors ascribed depressed growth rates in an exploited brown trout population to a selection process operating on a strictly heritable trait. Handford _et al_. (1977) demonstrated that gillnet fisheries are highly selective of large, fast-growing individuals and suggested that this will lend to the evolution of slower growth rate (ie. to smaller size at age). Similar processes could operate on the Lake Erie perch population in view of the intense and highly selective fishing pressure currently exerted by the commercial fishing industry.

Table 4.3-1. Regressions of fork length (L, mm) on scale radius (S, 80x mm) for pooled sexes of fish species captured annually by trap nets in Long Point Bay, Lake Erie (1971-1983). Standard intercepts (see text) replaced those shown in this table when backcalculations were performed.

| SPECIES | YEAR | SAMPLE SIZE | REGRESSION | CORREL. COEFF. | SPECIES | YEAR | SAMPLE SIZE | REGRESSION | CORREL. COEFF. |
|---|---|---|---|---|---|---|---|---|---|
| Yellow Perch | 1971 | 135 | L = 52.6 + 0.68s | 0.942 | Smallmouth Bass | 1972 | 133 | L = 119.5 + 0.55s | 0.830 |
| | 1972 | 381 | L = 40.8 + 0.77s | 0.887 | | 1973 | 152 | L = 114.4 + 0.50s | 0.929 |
| | 1973 | 233 | L = 46.5 + 0.69s | 0.844 | | 1974 | 138 | L = 89.7 + 0.88s | 0.845 |
| | 1974 | 181 | L = 51.3 + 0.73s | 0.918 | | 1975 | 58 | L = 49.0 + 1.07s | 0.857 |
| | 1975 | 218 | L = 60.2 + 0.63s | 0.803 | | 1976 | 78 | L = 66.2 + 0.61s | 0.927 |
| | 1976 | 317 | L = 29.7 + 0.56s | 0.965 | | 1977 | 94 | L = 75.4 + 0.59s | 0.951 |
| | 1977 | 201 | L = 30.1 + 0.57s | 0.974 | | 1978 | 111 | L = 64.7 + 0.60s | 0.965 |
| | 1978 | 283 | L = 28.6 + 0.58s | 0.973 | | 1980 | 81 | L = 41.8 + 0.65s | 0.911 |
| | 1980 | 1531 | L = 36.0 + 0.54s | 0.878 | | 1981 | 161 | L = 95.5 + 0.53s | 0.869 |
| | 1981 | 2577 | L = 45.2 + 0.51s | 0.914 | | 1982 | 226 | L = 60.8 + 0.61s | 0.939 |
| | 1982 | 2032 | L = 33.6 + 0.54s | 0.952 | | 1983 | 90 | L = 71.3 + 0.57s | 0.941 |
| | 1983 | 1448 | L = 34.6 + 0.54s | 0.957 | | | | | |
| Rock Bass | 1974 | 98 | L = 62.8 + 0.41s | 0.900 | White Bass | 1971 | 193 | L = 55.6 + 0.58s | 0.960 |
| | 1975 | 189 | L = 63.4 + 0.40s | 0.848 | | 1972 | 240 | L = 45.3 + 0.58s | 0.960 |
| | 1976 | 131 | L = 49.0 + 0.32s | 0.883 | | 1973 | 48 | L = 63.1 + 0.50s | 0.936 |
| | 1977 | 161 | L = 56.9 + 0.33s | 0.874 | | 1974 | 26 | L = 21.3 + 0.70s | 0.882 |
| | 1978 | 116 | L = 68.0 + 0.28s | 0.790 | | 1975 | 40 | L = 74.8 + 0.51s | 0.866 |
| | 1980 | 1373 | L = 32.4 + 0.36s | 0.849 | | 1976 | 59 | L = 46.7 + 0.50s | 0.979 |
| | 1981 | 2571 | L = 58.3 + 0.32s | 0.839 | | 1977 | 39 | L = 37.6 + 0.54s | 0.987 |
| | 1982 | 3509 | L = 69.0 + 0.26s | 0.795 | | 1978 | 209 | L = 36.2 + 0.54s | 0.958 |
| | 1983 | 1930 | L = 82.8 + 0.25s | 0.752 | | 1980 | 22 | L = 29.4 + 0.54s | 0.948 |
| | | | | | | 1981 | 774 | L = 50.0 + 0.48s | 0.931 |
| | | | | | | 1982 | 260 | L = 31.4 + 0.55s | 0.979 |
| | | | | | | 1983 | 57 | L = 45.7 + 0.49s | 0.966 |

Table 4.3-2. Functional regressions of $\mathrm{Log}_{10}$ weight (g) on $\mathrm{Log}_{10}$ fork length (mm) for yellow perch and rock bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1971-1983). Summarized by year of capture and period.

| YEAR OR PERIOD | YELLOW PERCH N | YELLOW PERCH REGRESSION | r | ROCK BASS N | ROCK BASS REGRESSION | r |
|---|---|---|---|---|---|---|
| 1971 | 127 | Log Wt = -5.447 + 3.281(Log Lt) | 0.99 | | No Data | |
| 1972 | 114 | Log Wt = -5.310 + 3.222(Log Lt) | 0.97 | | No Data | |
| 1973 | 215 | Log Wt = -5.178 + 3.146(Log Lt) | 0.98 | | No Data | |
| 1974 | 143 | Log Wt = -5.121 + 3.129(Log Lt) | 0.96 | 98 | Log Wt = -4.668 + 3.014(Log Lt) | 0.97 |
| 1975 | 208 | Log Wt = -5.031 + 3.095(Log Lt) | 0.96 | 171 | Log Wt = -4.116 + 2.788(Log Lt) | 0.93 |
| 1976 | 246 | Log Wt = -5.610 + 3.339(Log Lt) | 0.98 | 114 | Log Wt = -4.472 + 2.939(Log Lt) | 0.96 |
| 1977 | 186 | Log Wt = -5.319 + 3.219(Log Lt) | 0.99 | 134 | Log Wt = -4.295 + 2.868(Log Lt) | 0.98 |
| 1978 | 202 | Log Wt = -4.676 + 2.939(Log Lt) | 0.92 | 98 | Log Wt = -4.546 + 2.978(Log Lt) | 0.95 |
| 1980 | 1309 | Log Wt = -5.224 + 3.162(Log Lt) | 0.96 | 1316 | Log Wt = -4.887 + 3.116(Log Lt) | 0.95 |
| 1981 | 2398 | Log Wt = -5.031 + 3.106(Log Lt) | 0.95 | 2570 | Log Wt = -4.391 + 2.904(Log Lt) | 0.95 |
| 1982 | 1894 | Log Wt = -5.535 + 3.315(Log Lt) | 0.97 | 1586 | Log Wt = -4.491 + 2.957(Log Lt) | 0.96 |
| 1983 | 1346 | Log Wt = -5.549 + 3.308(Log Lt) | 0.98 | 1932 | Log Wt = -5.087 + 3.208(Log Lt) | 0.91 |
| BASELINE | | MALES | | | | |
| | 67 | Log Wt = -4.872 + 3.011(Log Lt) | | | No Data | |
| | | FEMALES | | | | |
| | 78 | Log Wt = -5.129 + 3.132(Log Lt) | | | No Data | |
| | | SEXES COMBINED | | | | |
| | 312 | Log Wt = -5.178 + 3.150(Log Lt) | | | No Data | |
| COMMISSIONING | | MALES | | | | |
| | 137 | Log Wt = -5.384 + 3.212(Log Lt) | | | No Data | |
| | | FEMALES | | | | |
| | 159 | Log Wt = -5.560 + 3.327(Log Lt) | | | No Data | |
| | | SEXES COMBINED | | | | |
| | 903 | Log Wt = -5.043 + 3.100(Log Lt) | | 615 | Log Wt = -4.446 + 2.925(Log Lt) | |
| OPERATIONAL | | MALES | | | | |
| | 978 | Log Wt = -4.741 + 2.954(Log Lt) | | 1060 | Log Wt = -4.571 + 2.982(Log Lt)* | |
| | | FEMALES | | | | |
| | 3296 | Log Wt = -5.451 + 3.264(Log Lt) | | 1962 | Log Wt = -4.479 + 2.944(Log Lt)* | |
| | | SEXES COMBINED | | | | |
| | 7043 | Log Wt = -5.368 + 3.226(Log Lt) | | 7180 | Log Wt = -4.700 + 3.041(Log Lt)* | |

* ordinary regression statistics rather than functional regression statistics.

Table 4.3-3. Spring age and year-class composition of yellow perch trapnet catches at Nanticoke, Long Point Bay, Lake Erie (1974-1983).[1]

| YEAR OF CAPTURE | | AGE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | II | III | IV | V | VI | VII | VIII | IX | X | XI | N |
| 1974 | Year Class | 1972 | 1971 | 1970 | 1969 | 1968 | 1967 | 1966 | 1965 | | | |
| | % | 14.4 | 52.4 | 19.0 | 4.4 | 4.8 | 2.7 | 2.1 | 0.3 | | | 857 |
| 1975 | Year Class | 1973 | 1972 | 1971 | 1970 | 1969 | 1968 | | | | | |
| | % | 3.8 | 37.6 | 49.4 | 6.5 | 1.9 | 0.8 | | | | | 163 |
| 1976 | Year Class | 1974 | 1973 | 1972 | 1971 | 1970 | 1969 | 1968 | 1967 | 1966 | | |
| | % | 1.8 | 33.4 | 15.4 | 28.7 | 8.1 | 4.5 | 5.6 | 2.3 | 0.3 | | 224 |
| 1977 | Year Class | 1975 | 1974 | 1973 | 1972 | 1971 | 1970 | 1969 | 1968 | 1967 | | |
| | % | 13.0 | 32.3 | 21.7 | 8.5 | 12.0 | 8.2 | 1.9 | 1.9 | 0.6 | | 354 |
| 1978 | Year Class | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | 1970 | 1969 | | | |
| | % | 4.1 | 38.5 | 25.7 | 12.2 | 3.8 | 10.6 | 3.1 | 1.9 | | | 660 |
| 1980 | Year Class | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | 1970 | | |
| | % | 0.4 | 67.2 | 12.4 | 6.6 | 3.8 | 5.1 | 2.6 | 1.7 | 0.2 | | 531 |
| 1981 | Year Class | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | | |
| | % | 1.4 | 50.9 | 34.7 | 4.1 | 4.0 | 2.4 | 1.9 | 0.4 | 0.1 | | 752 |
| 1982 | Year Class | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | |
| | % | 0.5 | 67.6 | 18.2 | 6.8 | 1.8 | 2.1 | 1.1 | 1.0 | 0.7 | 0.2 | 1009 |
| 1983 | Year Class | 1981 | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | |
| | % | 2.2 | 39.9 | 34.8 | 6.9 | 7.5 | 2.8 | 3.2 | 2.1 | 0.2 | 0.4 | 534 |

[1] 1974-1978 values are estimated from age-length keys (see Section 3.2.1)

Table 4.3-4. Spring age and year-class composition of rock bass catches from Nanticoke trap nets, Long Point Bay, Lake Erie (1974-1983).[1]

| YEAR OF CAPTURE | | AGE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | II | III | IV | V | VI | VII | VIII | IX | X | XI | N |
| 1974 | Year Class | 1972 | 1971 | 1970 | 1969 | 1968 | 1967 | 1966 | 1965 | 1964 | | 756 |
| | % | 0.1 | 1.7 | 16.3 | 16.3 | 17.1 | 25.0 | 18.6 | 4.3 | 0.7 | | |
| 1975 | Year Class | 1973 | 1972 | 1971 | 1970 | 1969 | 1968 | 1967 | 1966 | 1965 | | 479 |
| | % | 0.1 | 2.7 | 23.4 | 19.8 | 23.6 | 13.5 | 11.0 | 2.6 | 3.4 | | |
| 1976 | Year Class | | 1973 | 1972 | 1971 | 1970 | 1969 | 1968 | 1967 | 1966 | 1965 | 934 |
| | % | | 1.3 | 6.7 | 35.5 | 16.8 | 10.6 | 15.2 | 10.6 | 3.0 | 0.5 | |
| 1977 | Year Class | 1975 | 1974 | 1973 | 1972 | 1971 | 1970 | 1969 | 1968 | 1967 | 1966 | 920 |
| | % | 0.1 | 0.6 | 6.6 | 14.0 | 25.8 | 22.8 | 12.2 | 13.2 | 3.8 | 1.0 | |
| 1978 | Year Class | | | 1974 | 1973 | 1972 | 1971 | 1970 | 1969 | 1968 | | 934 |
| | % | | | 2.2 | 10.8 | 11.7 | 48.8 | 20.0 | 5.4 | 1.0 | | |
| 1980 | Year Class | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | 1970 | 1969 | 1373 |
| | % | 0.9 | 22.7 | 12.4 | 16.5 | 14.1 | 17.1 | 11.4 | 4.2 | 0.7 | 0.1 | |
| 1981 | Year Class | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | 1970 | 2573 |
| | % | 0.4 | 11.9 | 55.5 | 10.1 | 8.9 | 4.7 | 4.1 | 3.6 | 0.6 | 0.1 | |
| 1982 | Year Class | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | 2527 |
| | % | 0.6 | 3.2 | 23.3 | 52.4 | 8.2 | 4.6 | 4.2 | 1.9 | 1.2 | 0.4 | |
| 1983 | Year Class | 1981 | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | 1937 |
| | % | 0.1 | 2.6 | 9.4 | 32.7 | 45.4 | 3.8 | 2.7 | 1.4 | 1.5 | 0.2 | |

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[1] 1974-1978 values are estimated from age-length keys (see Section 3.2-1)

Table 4.3-5. Spring age and year-class composition of smallmouth bass[1] and white bass[2] catches from Nanticoke trap nets, Long Point Bay, Lake Erie (1974-1983).

| | | SMALLMOUTH BASS (Age, years) | | | | | | | | | | WHITE BASS (Age, years) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | | I | II | III | IV | V | VI | VII | VIII | IX | N | 0 | I | II | III | IV | N |
| 1974 | Year Class | 1973 | 1972 | 1971 | 1970 | 1969 | 1968 | 1967 | | | | | 1973 | 1972 | 1971 | 1970 | |
| | % | 1.5 | 9.4 | 42.0 | 38.4 | 4.4 | 2.2 | 2.2 | | | 138 | | 44.0 | 20.0 | 20.0 | 16.0 | 25 |
| 1975 | Year Class | | 1973 | 1972 | 1971 | 1970 | 1969 | 1968 | 1967 | | | | 1974 | 1973 | 1972 | 1971 | |
| | % | | 6.9 | 8.6 | 62.1 | 6.9 | 3.5 | 8.6 | 3.5 | | 58 | | 67.6 | 29.7 | 0.0 | 2.7 | 37 |
| 1976 | Year Class | | 1974 | 1973 | 1972 | 1971 | 1970 | 1969 | 1968 | | | | 1975 | 1974 | 1973 | 1972 | |
| | % | | 1.4 | 36.8 | 5.7 | 50.2 | 3.0 | 1.5 | 1.5 | | 120 | | 52.5 | 42.4 | 3.4 | 1.7 | 59 |
| 1977 | Year Class | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | 1970 | 1969 | 1968 | | | 1976 | 1975 | 1974 | | |
| | % | 0.7 | 6.4 | 17.3 | 38.0 | 8.8 | 24.4 | 1.5 | 1.5 | 1.5 | 155 | | 56.3 | 31.3 | 12.5 | | 32 |
| 1978 | Year Class | | 1976 | 1975 | 1974 | 1973 | 1972 | 1971 | 1970 | 1969 | | | 1977 | 1976 | 1975 | 1974 | |
| | % | | 12.2 | 15.7 | 19.0 | 36.8 | 4.1 | 8.2 | 1.4 | 2.7 | 191 | | 94.5 | 4.0 | 0.0 | 1.5 | 199 |
| 1980 | Year Class | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | 1972 | | | 1980 | 1979 | 1978 | 1977 | | |
| | % | 2.4 | 15.7 | 56.6 | 8.4 | 6.0 | 4.8 | 3.6 | 2.4 | | 83 | 24.0 | 56.0 | 12.0 | 8.0 | | 332 |
| 1981 | Year Class | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | | | 1981 | 1980 | 1979 | 1978 | | |
| | % | 8.1 | 11.6 | 52.6 | 22.0 | 3.5 | 0.6 | 0.6 | 1.2 | | 173 | 0.1 | 98.4 | 1.3 | 0.3 | | 973 |
| 1982 | Year Class | 1981 | 1980 | 1979 | 1978 | 1977 | 1976 | 1975 | 1974 | 1973 | | 1982 | 1981 | 1980 | | | |
| | % | 4.8 | 50.7 | 5.7 | 22.9 | 8.4 | 4.0 | 1.8 | 0.4 | 0.9 | 227 | 6.0 | 73.1 | 20.3 | | | 703 |
| 1983 | Year Class | 1982 | 1981 | 1980 | 1979 | 1978 | 1977 | | | | | | 1982 | 1981 | 1980 | | |
| | % | 2.3 | 12.4 | 36.0 | 27.0 | 15.7 | 6.7 | | | | 89 | | 54.2 | 44.1 | 1.7 | | 255 |

[1] 1976-1978 age compositions are estimated from length-frequency data (see Section 3.2.1)

[2] Data are entirely from aged fish (see Section 3.2.1)

Table 4.3-6. Analyses of variance testing the effects of year and sex on age specific empirical fork lengths, backcalculated fork lengths at last annulus and last increments of growth for yellow perch and rock bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1980-1983).

| | | YELLOW PERCH | | | | | | | | | ROCK BASS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Empirical Fork Length at Capture (spring) | | | Fork Length at Last Annulus | | | Last Increment of Growth | | | Empirical Fork Length at Capture (spring) | | | Fork Length at Last Annulus | | | Last Increment of Growth | | |
| Source of Variation | | df | SS | F | df | SS | F | df | SS | F | df | SS | F | df | SS | F | df | SS | F |
| AGE = 3 | | | | | | | | | | | | | | | | | | | |
| Main Effects: | Year | 3 | 25641 | 45.37$^a$ | 3 | 39590 | 53.87$^a$ | 3 | 12444 | 41.05$^a$ | 3 | 764 | 0.50 | 3 | 2354 | 2.81$^d$ | 3 | 1256 | 5.72$^a$ |
| | Sex | 1 | 7693 | 40.84$^b$ | 1 | 33293 | 135.92$^a$ | 1 | 47087 | 466.00$^a$ | 1 | 544 | 1.07 | 1 | 225 | 0.81 | 1 | 330 | 4.50$^d$ |
| | Year x Sex | 3 | 629 | 1.11 | 3 | 1552 | 2.11 | 3 | 735 | 2.43 | 2 | 790 | 0.78 | 3 | 374 | 0.45 | 3 | 178 | 0.81 |
| | Explained | 7 | 39990 | | 7 | 83477 | 48.68$^a$ | 7 | 74824 | 105.79$^a$ | 6 | 1498 | 0.49 | 7 | 3055 | 1.56 | 7 | 1775 | 3.47$^b$ |
| | Residual | 1392 | 262210 | | 2748 | 673115 | | 2748 | 277670 | | 56 | 28521 | | 599 | 167255 | | 599 | 43839 | |
| | Total | 1399 | 302199 | | 2755 | 756592 | | 2755 | 352494 | | 62 | 30019 | | 606 | 170310 | | 606 | 45614 | |
| AGE = 4 | | | | | | | | | | | | | | | | | | | |
| Main Effects: | Year | 3 | 29251 | 21.51$^a$ | 3 | 46033 | 37.39$^a$ | 3 | 4362 | 24.60$^a$ | 3 | 23477 | 36.76$^a$ | 3 | 39153 | 49.75$^a$ | 3 | 2647 | 12.52$^a$ |
| | Sex | 1 | 105448 | 232.68$^a$ | 1 | 169018 | 411.83$^a$ | 1 | 18060 | 305.60$^a$ | 1 | 8583 | 40.32$^a$ | 1 | 4777 | 18.21$^a$ | 1 | 1273 | 18.06$^a$ |
| | Year x Sex | 3 | 1881 | 1.38 | 3 | 11646 | 9.46$^a$ | 3 | 910 | 5.13$^b$ | 3 | 1457 | 2.28 | 3 | 558 | 0.71 | 3 | 48 | 0.23 |
| | Explained | 7 | 150632 | 47.48$^a$ | 7 | 238044 | 82.86$^a$ | 7 | 24426 | 59.10$^a$ | 7 | 41565 | 27.89$^a$ | 7 | 52730 | 28.72$^a$ | 7 | 5566 | 11.28$^a$ |
| | Residual | 583 | 264208 | | 947 | 388660 | | 947 | 55963 | | 592 | 126023 | | 1479 | 387946 | | 1479 | 104246 | |
| | Total | 590 | 414840 | | 954 | 626704 | | 954 | 80389 | | 599 | 167589 | | 1486 | 440676 | | 1486 | 109812 | |
| AGE = 5 | | | | | | | | | | | | | | | | | | | |
| Main Effects: | Year | 3 | 16685 | 7.12$^b$ | 3 | 24933 | 11.18$^a$ | 3 | 496 | 2.99$^d$ | 3 | 3153 | 5.51$^b$ | 3 | 5474 | 8.34$^a$ | 3 | 9155 | 47.95$^a$ |
| | Sex | 1 | 77952 | 99.75$^a$ | 1 | 122809 | 165.19$^a$ | 1 | 3685 | 66.63$^a$ | 1 | 9226 | 48.39$^a$ | 1 | 19652 | 89.85$^a$ | 1 | 1697 | 26.66$^a$ |
| | Year x Sex | 3 | 6295 | 2.69$^d$ | 3 | 7697 | 3.45$^d$ | 3 | 160 | 0.96 | 3 | 563 | 0.98 | 3 | 1360 | 2.07 | 3 | 96 | 0.50 |
| | Explained | 7 | 128797 | 23.55$^a$ | 7 | 18700 | 35.93$^a$ | 7 | 5224 | 13.49$^a$ | 7 | 25440 | 19.06$^a$ | 7 | 37410 | 24.44$^a$ | 7 | 12231 | 27.45$^a$ |
| | Residual | 143 | 111749 | | 176 | 130844 | | 176 | 9734 | | 787 | 150046 | | 1141 | 249546 | | 1141 | 72623 | |
| | Total | 150 | 240547 | | 183 | 317839 | | 183 | 14958 | | 794 | 175486 | | 1148 | 286956 | | 1148 | 84853 | |
| AGE = 6 | | | | | | | | | | | | | | | | | | | |
| Main Effects: | Year | 3 | 959 | 0.65 | 3 | 68 | 0.05 | 1 | 425 | 3.27$^d$ | 3 | 10373 | 22.76$^a$ | 3 | 16626 | 35.17$^a$ | 3 | 730 | 5.91$^a$ |
| | Sex | 1 | 13906 | 28.40$^a$ | 1 | 21962 | 44.87$^a$ | 1 | 128 | 2.94 | 1 | 13383 | 88.08$^a$ | 1 | 21891 | 138.90$^a$ | 1 | 262 | 6.36$^c$ |
| | Year x Sex | 2 | 347 | 0.35 | 2 | 712 | 0.73 | 2 | 135 | 1.55 | 3 | 460 | 1.01 | 3 | 67 | 0.14 | 3 | 265 | 2.15 |
| | Explained | 6 | 21033 | 7.16$^a$ | 6 | 26014 | 8.86$^a$ | 6 | 681 | 2.61$^d$ | 7 | 42198 | 39.68$^a$ | 7 | 53882 | 48.84$^a$ | 7 | 1786 | 6.20$^a$ |
| | Residual | 76 | 37216 | | 91 | 44544 | | 91 | 3948 | | 646 | 98153 | | 945 | 148933 | | 945 | 38901 | |
| | Total | 82 | 58243 | | 97 | 70557 | | 97 | 4628 | | 653 | 140350 | | 952 | 202814 | | 952 | 40687 | |
| AGE = 7 | | | | | | | | | | | | | | | | | | | |
| Main Effects: | Year | | | | | | | | | | 3 | 1076 | 1.73 | 3 | 1906 | 3.06$^d$ | 3 | 175 | 2.57 |
| | Sex | | | | | | | | | | 1 | 11195 | 54.12$^a$ | 1 | 13165 | 63.31$^a$ | 1 | 69 | 3.03 |
| | Year x Sex | | | | | | | | | | 3 | 1268 | 2.04 | 3 | 559 | 0.90 | 3 | 65 | 0.96 |
| | Explained | | | | | | | | | | 7 | 15038 | 10.39$^a$ | 7 | 21835 | 15.00$^a$ | 7 | 266 | 1.68 |
| | Residual | | | | | | | | | | 263 | 54403 | | 361 | 75070 | | 361 | 8179 | |
| | Total | | | | | | | | | | 270 | 69440 | | 368 | 96904 | | 386 | 8444 | |

$^a$ significant at P = 0.0001

$^b$ significant at P < 0.001

$^c$ significant at P < 0.01

$^d$ significant at P < 0.05

Table 4.3-7. Mean backcalculated fork lengths at last annulus (mm) and last increments of growth (mm) for male and female yellow perch taken by eight foot trap nets at Nanticoke, Long Point Bay, Lake Erie (1980-1983).[1] [2]

|  |  | AGE |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | II |  |  | III |  |  | IV |  |  | V |  |  | VI |  |  | VII |  |  | VIII |  |  |
| Year | Sex | (N) Mean | Upper CL | Lower CL | (N) Mean | Upper CL | Lower CL | (N) Mean | Upper CL | Lower CL | (N) Mean | Upper CL | Lower CL | (N) Mean | Upper CL | Lower CL | (N) Mean | Upper CL | Lower CL | (N) Mean | Upper CL | Lower CL |
|  |  | Length-at-Last-Annulus |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1980 | Males | (45)<br>139 | 143 | 135 | (264)<br>179 | 181 | 177 | (59)<br>194 | 200 | 188 | (14)<br>235 | 255 | 215 | (2)<br>239 |  |  | (4)<br>300 | 353 | 247 | (2)<br>282 |  |  |
|  | Females | (146)<br>146 | 148 | 143 | (544)<br>184 | 185 | 182 | (55)<br>222 | 232 | 213 | (32)<br>279 | 286 | 272 | (26)<br>294 | 303 | 285 | (26)<br>309 | 318 | 301 | (16)<br>322 | 330 | 315 |
| 1981 | Males | (100)<br>139 | 141 | 136 | (304)<br>167 | 168 | 165 | (203)<br>179 | 181 | 177 | (14)<br>197 | 212 | 182 | (3)<br>240 |  |  | (1)<br>274 |  |  | (1)<br>272 |  |  |
|  | Females | (343)<br>132 | 134 | 131 | (371)<br>174 | 175 | 172 | (107)<br>197 | 202 | 192 | (15)<br>242 | 265 | 218 | (10)<br>291 | 300 | 281 | (1)<br>313 |  |  | (5)<br>316 | 339 | 293 |
| 1982 | Males | (13)<br>151 | 160 | 143 | (265)<br>171 | 173 | 169 | (123)<br>183 | 186 | 180 | (26)<br>203 | 211 | 196 |  |  |  | (2)<br>284 |  |  | (1)<br>329 |  |  |
|  | Females | (60)<br>147 | 150 | 143 | (451)<br>179 | 180 | 178 | (64)<br>218 | 224 | 212 | (34)<br>271 | 282 | 261 | (13)<br>295 | 310 | 280 | (12)<br>325 | 335 | 315 |  |  |  |
| 1983 | Males | (40)<br>140 | 143 | 136 | (103)<br>171 | 173 | 168 | (148)<br>180 | 182 | 179 | (8)<br>192 | 204 | 179 | (2)<br>223 |  |  |  |  |  | (1)<br>328 |  |  |
|  | Females | (206)<br>137 | 139 | 136 | (194)<br>182 | 184 | 180 | (110)<br>211 | 216 | 206 | (29)<br>267 | 277 | 257 | (34)<br>300 | 308 | 293 | (15)<br>313 | 326 | 301 | (14)<br>328 | 339 | 317 |
|  |  | Last-Increment-of-Growth |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1980 | Males | (45)<br>59 | 61 | 56 | (264)<br>39 | 40 | 38 | (59)<br>25 | 27 | 23 | (14)<br>19 | 22 | 16 | (2)<br>12 |  |  | (4)<br>14 | 24 | 4 | (2)<br>16 |  |  |
|  | Females | (146)<br>64 | 66 | 62 | (544)<br>49 | 50 | 48 | (55)<br>33 | 35 | 30 | (32)<br>28 | 31 | 26 | (26)<br>20 | 21 | 18 | (26)<br>14 | 16 | 12 | (16)<br>12 | 14 | 11 |
| 1981 | Males | (100)<br>64 | 65 | 63 | (304)<br>42 | 43 | 41 | (203)<br>23 | 24 | 22 | (14)<br>16 | 17 | 14 | (3)<br>19 |  |  | (1)<br>10 |  |  | (1)<br>3 |  |  |
|  | Females | (343)<br>62 | 63 | 60 | (379)<br>51 | 52 | 50 | (107)<br>31 | 33 | 29 | (15)<br>22 | 28 | 17 | (10)<br>18 | 20 | 15 | (1)<br>8 |  |  | (5)<br>9 | 13 | 5 |
| 1982 | Males | (13)<br>61 | 70 | 52 | (265)<br>44 | 45 | 43 | (123)<br>27 | 28 | 25 | (26)<br>19 | 21 | 16 |  |  |  | (2)<br>12 |  |  | (1)<br>8 |  |  |
|  | Females | (60)<br>61 | 63 | 58 | (451)<br>54 | 55 | 53 | (64)<br>39 | 42 | 36 | (34)<br>28 | 31 | 25 | (13)<br>24 | 30 | 18 | (12)<br>12 | 14 | 10 |  |  |  |
| 1983 | Males | (40)<br>62 | 65 | 59 | (103)<br>41 | 43 | 39 | (148)<br>22 | 23 | 21 | (8)<br>16 | 19 | 13 | (2)<br>11 |  |  |  |  |  | (1)<br>7 |  |  |
|  | Females | (206)<br>62 | 63 | 60 | (194)<br>48 | 50 | 47 | (110)<br>32 | 34 | 31 | (29)<br>30 | 34 | 26 | (34)<br>18 | 21 | 16 | (15)<br>15 | 18 | 12 | (14)<br>10 | 12 | 9 |

[1] Upper and Lower CL = 95% confidence intervals

[2] (N) = sample size

Table 4.3-8. Von Bertalanffy growth parameters and growth indices (ω) for yellow perch and rock bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1972-1983). Parameters were generated from Ford-Walford plots and the method of Bayley (1977). Data were summarized by period.

| PERIOD | AGE GROUP | SEX | $L_\infty$ |  | K |  | $t_o$ |  | r |  | ω |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | BAYLEY | WALFORD | BAYLEY | WALFORD | BAYLEY | WALFORD | BAYLEY | WALFORD | BAYLEY | WALFORD |
|  |  |  |  |  | YELLOW PERCH |  |  |  |  |  |  |  |
| Baseline | 1-7 | Males | 283.4 | 314.3 | 0.3947 | 0.2708 | -0.0498 | -0.3582 | 0.9838 | -0.9986 | 111.9 | 85.1 |
|  | 1-8 | Females | 355.1 | 356.7 | 0.2906 | 0.2861 | -0.0250 | -0.0710 | 0.9992 | -0.9997 | 103.2 | 102.1 |
|  | 1-8 | Combined | 360.5 | 364.4 | 0.2653 | 0.2568 | -0.0627 | -0.1052 | 0.9967 | -0.9994 | 95.6 | 93.6 |
| Commissioning | 1-8 | Males | 409.5 | 491.4 | 0.1831 | 0.1285 | -0.2919 | -0.5216 | 0.9678 | 0.9964 | 75.0 | 63.2 |
|  | 1-8 | Females | 368.6 | 363.0 | 0.2564 | 0.2633 | -0.0337 | 0.0631 | 0.9998 | -0.9998 | 94.5 | 95.6 |
|  | 1-8 | Combined | 382.6 | 379.4 | 0.2216 | 0.2305 | -0.1426 | -0.0443 | -0.9979 | -0.9992 | 84.8 | 87.5 |
| Operational | 1-8 | Males | 358.2 | 533.4 | 0.2024 | 0.0959 | -0.1709 | -0.6856 | -0.9347 | -0.9926 | 72.5 | 51.2 |
|  | 1-8 | Females | 411.9 | 353.2 | 0.1986 | 0.3198 | -0.0467 | 0.4995 | -0.9892 | -0.9968 | 81.8 | 112.9 |
|  | 1-8 | Combined | 418.1 | 384.7 | 0.1845 | 0.2152 | -0.1002 | 0.2779 | 0.9820 | -0.9957 | 77.1 | 82.8 |
|  |  |  |  |  | ROCK BASS |  |  |  |  |  |  |  |
| Commissioning | 1-10 | Combined | 358.0 | 284.2 | 0.1408 | 0.2647 | -0.2542 | 0.4503 | 0.9703 | -0.9975 | 50.4 | 75.2 |
| Operational | 1-10 | Combined | 377.0 | 283.5 | 0.1303 | 0.2726 | -0.2379 | 0.4963 | 0.9601 | -0.9985 | 49.1 | 77.3 |

Table 4.3-9. Mean backcalculated fork lengths at last annulus (mm) and last increments of growth (mm) for male and female rock bass captured in eight foot trap nets at Nanticoke, Long Point Bay, Lake Erie (1980-1983).[1,2]

| | | AGE | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | III | | | IV | | | V | | | VI | | | VII | | | VIII | | | IX | | |
| Year | Sex | (N)<br>Mean | Upper CL | Lower CL | (N)<br>Mean | Upper CL | Lower CL | (N)<br>Mean | Upper CL | Lower CL | (N)<br>Mean | Upper CL | Lower CL | (N)<br>Mean | Upper CL | Lower CL | (N)<br>Mean | Upper CL | Lower CL | (N)<br>Mean | Upper CL | Lower CL |
| | | Length-at-Last-Annulus | | | | | | | | | | | | | | | | | | | | |
| 1980 | Males | (177)<br>135 | 138 | 133 | (90)<br>179 | 183 | 175 | (118)<br>210 | 213 | 207 | (96)<br>234 | 238 | 231 | (132)<br>244 | 247 | 242 | (77)<br>256 | 259 | 253 | (28)<br>261 | 265 | 257 |
| | Females | (99)<br>135 | 139 | 130 | (61)<br>171 | 177 | 166 | (77)<br>197 | 200 | 194 | (73)<br>222 | 225 | 218 | (78)<br>229 | 232 | 226 | (57)<br>239 | 243 | 235 | (20)<br>242 | 247 | 237 |
| 1981 | Males | (136)<br>133 | 136 | 131 | (598)<br>167 | 168 | 166 | (53)<br>199 | 204 | 194 | (34)<br>226 | 230 | 223 | (17)<br>247 | 253 | 241 | (9)<br>251 | 261 | 241 | (7)<br>255 | 266 | 244 |
| | Females | (116)<br>132 | 135 | 130 | (418)<br>162 | 163 | 160 | (41)<br>194 | 199 | 189 | (25)<br>213 | 218 | 208 | (12)<br>222 | 234 | 211 | (9)<br>249 | 261 | 236 | (11)<br>248 | 256 | 240 |
| 1982 | Males | (17)<br>141 | 153 | 129 | (80)<br>180 | 184 | 176 | (209)<br>211 | 213 | 209 | (45)<br>233 | 237 | 228 | (22)<br>248 | 255 | 241 | (22)<br>263 | 267 | 258 | (14)<br>272 | 279 | 266 |
| | Females | (13)<br>143 | 155 | 131 | (46)<br>178 | 183 | 173 | (152)<br>197 | 199 | 195 | (28)<br>220 | 224 | 216 | (18)<br>236 | 241 | 230 | (21)<br>246 | 252 | 240 | (7)<br>255 | 266 | 244 |
| 1983 | Males | (16)<br>140 | 147 | 132 | (66)<br>172 | 176 | 167 | (235)<br>205 | 207 | 203 | (335)<br>224 | 226 | 223 | (31)<br>243 | 249 | 238 | (9)<br>255 | 262 | 249 | (11)<br>266 | 275 | 256 |
| | Females | (11)<br>134 | 138 | 130 | (41)<br>167 | 172 | 161 | (113)<br>196 | 199 | 194 | (179)<br>211 | 213 | 210 | (11)<br>233 | 244 | 222 | (19)<br>242 | 248 | 236 | (6)<br>242 | 259 | 226 |
| | | Last-Increment-of-Growth | | | | | | | | | | | | | | | | | | | | |
| 1980 | Males | (177)<br>44 | 45 | 43 | (90)<br>39 | 41 | 37 | (118)<br>30 | 32 | 28 | (96)<br>21 | 22 | 19 | (132)<br>14 | 15 | 13 | (77)<br>11 | 13 | 9 | (28)<br>9 | 10 | 8 |
| | Females | (99)<br>43 | 45 | 42 | (61)<br>34 | 37 | 32 | (77)<br>27 | 29 | 25 | (73)<br>21 | 22 | 19 | (78)<br>14 | 15 | 13 | (57)<br>13 | 15 | 12 | (20)<br>8 | 10 | 7 |
| 1981 | Males | (136)<br>43 | 45 | 42 | (598)<br>39 | 40 | 38 | (53)<br>30 | 32 | 27 | (34)<br>18 | 21 | 15 | (17)<br>13 | 15 | 11 | (9)<br>11 | 12 | 9 | (7)<br>8 | 11 | 6 |
| | Females | (16)<br>42 | 43 | 40 | (418)<br>37 | 38 | 36 | (41)<br>28 | 31 | 26 | (25)<br>16 | 19 | 13 | (12)<br>13 | 16 | 10 | (9)<br>9 | 11 | 8 | (11)<br>10 | 12 | 7 |
| 1982 | Males | (17)<br>51 | 57 | 46 | (80)<br>44 | 45 | 42 | (209)<br>37 | 38 | 36 | (45)<br>20 | 23 | 17 | (22)<br>16 | 18 | 14 | (22)<br>12 | 13 | 11 | (14)<br>9 | 11 | 8 |
| | Females | (13)<br>47 | 56 | 39 | (46)<br>41 | 45 | 38 | (152)<br>33 | 35 | 32 | (28)<br>19 | 21 | 17 | (18)<br>14 | 16 | 12 | (21)<br>11 | 13 | 10 | (7)<br>10 | 13 | 8 |
| 1983 | Males | (16)<br>45 | 49 | 42 | (66)<br>39 | 41 | 37 | (235)<br>32 | 33 | 31 | (335)<br>20 | 22 | 19 | (31)<br>14 | 16 | 12 | (9)<br>11 | 14 | 9 | (11)<br>8 | 10 | 7 |
| | Females | (11)<br>44 | 50 | 38 | (41)<br>36 | 39 | 33 | (113)<br>29 | 31 | 28 | (179)<br>17 | 18 | 16 | (11)<br>12 | 14 | 9 | (19)<br>10 | 12 | 9 | (6)<br>9 | 12 | 7 |

Table 4.3-10. Analyses of variance testing the effects of year and sex on age specific empirical fork lengths, backcalculated fork lengths at last annulus and last increments of growth for smallmouth bass and white bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1980-1983).

| | | SMALLMOUTH BASS | | | | | | | | | WHITE BASS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Empirical Fork Length at Capture (spring) | | | Fork Length at Last Annulus | | | Last Increment of Growth | | | Empirical Fork Length at Capture (spring) | | | Fork Length at Last Annulus | | | Last Increment of Growth | | |
| Source of Variation | | df | SS | F | df | SS | F | df | SS | F | df | SS | F | df | SS | F | df | SS | F |
| AGE = 1 | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Year | | | | | | | | | | 1 | 584 | 8.61[b] | 3 | 6664 | 12.69[a] | | | |
| | Sex | | | | | | | | | | 1 | 3 | 0.04 | 1 | 18 | 0.10 | | | |
| | Year x Sex | | | | | | | | | | 1 | 37 | 0.55 | 3 | 959 | 1.83 | | | |
| | Explained | | | | | | | | | | 3 | 634 | 3.12[d] | 7 | 7803 | 6.37[a] | | | |
| | Residual | | | | | | | | | | 159 | 10773 | | 770 | 134724 | | | | |
| | Total | | | | | | | | | | 162 | 11406 | | 777 | 142527 | | | | |
| AGE = 2 | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Year | | | | 3 | 11113 | 11.02[a] | 3 | 6179 | 12.04[a] | 3 | 4462 | 4.39[c] | 3 | 22311 | 13.87[a] | 3 | 13553 | 20.39[a] |
| | Sex | | | | 1 | 236 | 0.70 | 1 | 462 | 2.70 | 1 | 60 | 0.18 | 1 | 709 | 1.32 | 1 | 833 | 3.76 |
| | Year x Sex | | | | 3 | 2690 | 2.67 | 3 | 2956 | 5.76[b] | 2 | 69 | 0.10 | 2 | 613 | 0.57 | 2 | 357 | 0.81 |
| | Explained | | | | 7 | 15209 | 6.46[a] | 7 | 10102 | 8.44[a] | 6 | 11435 | 5.62[a] | 6 | 22497 | 6.99[a] | 6 | 14047 | 10.57[a] |
| | Residual | | | | 73 | 24551 | | 73 | 12482 | | 52 | 11621 | | 67 | 35937 | | 67 | 14847 | |
| | Total | | | | 80 | 39760 | | 80 | 22584 | | 58 | 29055 | | 73 | 58434 | | 73 | 28894 | |
| AGE = 3 | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Year | | | | 3 | 27620 | 14.71[a] | 3 | 2207 | 4.55[c] | | | | | | | | | |
| | Sex | | | | 1 | 23 | 0.03 | 1 | 133 | 0.82 | | | | | | | | | |
| | Year x Sex | | | | 3 | 3833 | 1.50 | 3 | 338 | 0.70 | | | | | | | | | |
| | Explained | | | | 7 | 43454 | 7.28[b] | 7 | 3212 | 2.83[c] | | | | | | | | | |
| | Residual | | | | 140 | 119367 | | 140 | | | | | | | | | | | |
| | Total | | | | 147 | 162822 | | 147 | | | | | | | | | | | |
| AGE = 4 | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Year | 3 | 9841 | 10.50[a] | 3 | 23529 | 11.77[a] | 3 | 3685 | 10.63[a] | | | | | | | | | |
| | Sex | 1 | 977 | 3.13 | 1 | 119 | 0.18 | 1 | 35 | 0.30 | | | | | | | | | |
| | Year x Sex | 2 | 265 | 0.42 | 2 | 215 | 0.16 | 2 | 62 | 0.27 | | | | | | | | | |
| | Explained | 6 | 10962 | 5.85[b] | 6 | 25658 | 6.42[a] | 6 | 4285 | 6.18[a] | | | | | | | | | |
| | Residual | 44 | 13749 | | 74 | 49298 | | 74 | 8550 | | | | | | | | | | |
| | Total | 50 | 24711 | | 80 | 74956 | | 80 | 12834 | | | | | | | | | | |

[a] significant at P = 0.0001

[b] significant at P < 0.001

[c] significant at P < 0.01

[d] significant at P < 0.05

Table 4.3-11. Analyses of variance testing the effects of year and location (plume vs control) on empirical fork lengths, backcalculated fork lengths at last annulus and last increments of growth for yellow perch and rock bass taken at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1980-1983).

| | | YELLOW PERCH | | | | | | | | | ROCK BASS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Empirical Fork Length at Capture (spring) | | | Fork Length at Last Annulus | | | Last Increment of Growth | | | Empirical Fork Length at Capture (spring) | | | Fork Length at Last Annulus | | | Last Increment of Growth | | |
| Source of Variation | | df | SS | F | df | SS | F | df | SS | F | df | SS | F | df | SS | F | df | SS | F |
| | | | | | | | | | | AGE = 2 | | | | | | | | | |
| Main Effects: | Year | 3 | 2512 | $2.75^d$ | 3 | 24995 | $38.80^a$ | 3 | 201 | 0.52 | | | | | | | | | |
| | Location | 1 | 533 | 1.75 | 1 | 1631 | $7.60^c$ | 1 | 93 | 0.71 | | | | | | | | | |
| | Year x Loction | 2 | 548 | 0.90 | 3 | 2804 | $4.35^c$ | 3 | 395 | 1.01 | | | | | | | | | |
| | Explained | 6 | 2746 | 1.50 | 7 | 34105 | $22.69^a$ | 7 | 946 | 1.04 | | | | | | | | | |
| | Residual | 54 | 16434 | | 1220 | 261970 | | 1220 | 158431 | | | | | | | | | | |
| | Total | 60 | 19181 | | 1227 | 296075 | | 1227 | 159377 | | | | | | | | | | |
| | | | | | | | | | | AGE = 3 | | | | | | | | | |
| Main Effects: | Year | 3 | 6708 | $12.58^a$ | 3 | 9035 | $12.09^a$ | 3 | 19546 | $53.06^a$ | 3 | 362 | 0.17 | 3 | 2005 | 2.45 | 3 | 1895 | $8.27^a$ |
| | Location | 1 | 10825 | $60.91^a$ | 1 | 13701 | $55.00^a$ | 1 | 163 | 1.33 | 1 | 304 | 0.44 | 1 | 989 | 3.63 | 1 | 121 | 1.58 |
| | Year x Location | 3 | 2476 | $4.64^c$ | 3 | 10577 | $14.15^a$ | 3 | 1956 | $5.31^b$ | 3 | 2961 | 1.41 | 3 | 419 | 0.51 | 3 | 504 | 2.20 |
| | Explained | 7 | 26655 | $21.43^a$ | 7 | 43124 | $24.73^a$ | 7 | 25688 | $29.89^a$ | 7 | 3524 | 0.72 | 7 | 5670 | 2.97 | 7 | 2572 | $4.81^a$ |
| | Residual | 2118 | 376389 | | 3680 | 916768 | | 3680 | 451878 | | 71 | 49535 | | 719 | 196045 | | 719 | 54929 | |
| | Total | 2125 | 403044 | | 3687 | 959892 | | 3687 | 477566 | | 78 | 53059 | | 726 | 201714 | | 726 | 57501 | |
| | | | | | | | | | | AGE = 4 | | | | | | | | | |
| Main Effects: | Year | 3 | 5789 | $2.84^d$ | 3 | 5799 | $2.90^d$ | 3 | 2467 | $8.84^a$ | 3 | 14910 | $17.36^a$ | 3 | 34473 | $38.15^a$ | 3 | 4360 | $19.62^a$ |
| | Location | 1 | 382 | 0.56 | 1 | 1301 | 1.95 | 1 | 342 | $3.68^d$ | 1 | 143 | 0.50 | 1 | 308 | 1.02 | 1 | 0 | 0.00 |
| | Year x Location | 3 | 2718 | 1.31 | 3 | 6359 | $3.18^d$ | 3 | 717 | $2.57^d$ | 3 | 5272 | $6.14^b$ | 3 | 2907 | $3.22^d$ | 3 | 249 | 1.12 |
| | Explained | 7 | 16747 | $3.52^b$ | 7 | 24286 | $5.20^a$ | 7 | 3420 | $5.25^a$ | 7 | 23063 | $11.50^a$ | 7 | 43844 | $20.79^a$ | 7 | 5133 | $9.90^a$ |
| | Residual | 1016 | 690489 | | 1478 | 985417 | | 1478 | 137474 | | 895 | 256302 | | 2046 | | | 2046 | 151537 | |
| | Total | 1023 | 707236 | | 1485 | 1009704 | | 1485 | 140895 | | 902 | 279364 | | 2053 | | | 2053 | 156670 | |
| | | | | | | | | | | AGE = 5 | | | | | | | | | |
| Main Effects: | Year | 3 | 13988 | $3.30^d$ | 3 | 17256 | $3.92^c$ | 3 | 931 | $3.80^c$ | 3 | 985 | 1.58 | 3 | 1996 | $2.91^d$ | 3 | 10627 | $52.39^a$ |
| | Location | 1 | 13624 | $9.65^c$ | 1 | 12333 | $8.40^c$ | 1 | 184 | 2.25 | 1 | 342 | 1.64 | 1 | 588 | 2.58 | 1 | 253 | $3.74^d$ |
| | Year x Location | 3 | 4750 | 1.12 | 3 | 383 | 0.09 | 3 | 51 | 0.21 | 3 | 72 | 0.11 | 3 | 1272 | 1.86 | 3 | 494 | $2.44^d$ |
| | Explained | 7 | 65066 | $6.59^a$ | 7 | 72761 | $7.08^a$ | 7 | 1411 | $2.47^c$ | 7 | 2620 | 1.80 | 7 | 5090 | 3.19 | 7 | 12544 | $26.51^a$ |
| | Residual | 210 | 296354 | | 253 | 371312 | | 253 | 20645 | | 1321 | 274621 | | 1856 | 423601 | | 1856 | 125486 | |
| | Total | 217 | 361420 | | 260 | 444076 | | 260 | 22056 | | 1328 | 277241 | | 1863 | 428691 | | 1863 | 138030 | |
| | | | | | | | | | | AGE = 6 | | | | | | | | | |
| Main Effects: | Year | | | | | | | | | | 3 | 13385 | $21.77^a$ | 3 | 14558 | $24.20^a$ | 3 | 1044 | $8.28^a$ |
| | Location | | | | | | | | | | 1 | 467 | 2.28 | 1 | 63 | 0.31 | 1 | 37 | 0.88 |
| | Year x Location | | | | | | | | | | 3 | 1390 | 2.26 | 3 | 1789 | $2.97^d$ | 3 | 91 | 0.72 |
| | Explained | | | | | | | | | | 7 | 18021 | $12.56^a$ | 7 | 20881 | $14.87^a$ | 7 | 1412 | $4.80^a$ |
| | Residual | | | | | | | | | | 1050 | 215233 | | 1470 | 294830 | | 1470 | 61818 | |
| | Total | | | | | | | | | | 1057 | 233254 | | 1477 | 315711 | | 1477 | 63231 | |

[a] significant at $P = 0.0001$

[b] significant at $P < 0.001$

[c] significant at $P < 0.01$

[d] significant at $P < 0.05$

Table 4.3-12. Analyses of variance testing the effects of year, season and sex on age specific empirical fork lengths, backcalculated fork lengths at last annulus and last increments of growth for yellow perch and rock bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1980-1983).

| Source of Variation | | YELLOW PERCH | | | | | | | ROCK BASS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Empirical Fork Length at Capture | | Fork Length at Last Annulus | | Last Increment of Growth | | | Empirical Fork Length at Capture | | Fork Length at Last Annulus | | Last Increment of Growth | |
| | | df | SS | F | SS | F | SS | F | df | SS | F | SS | F | SS | F |
| AGE = 2 | | | | | | | | | | | | | | | |
| Main Effects: | Year | 3 | 1413 | 3.99$^c$ | 1734 | 3.31$^d$ | 849 | 2.56 | | | | | | | |
| | Season | 2 | 10198 | 30.92$^a$ | 13606 | 39.15$^a$ | 3365 | 14.85$^a$ | | | | | | | |
| | Sex | 1 | 606 | 4.63$^d$ | 4 | 0.03 | 4 | 0.04 | | | | | | | |
| | Year x Season | 6 | 565 | 0.72 | 1572 | 1.51 | 698 | 1.02 | | | | | | | |
| | Year x Sex | 3 | 473 | 1.05 | 567 | 1.09 | 263 | 0.77 | | | | | | | |
| | Season x Sex | 2 | 2237 | 8.54$^b$ | 139 | 0.40 | 256 | 1.10 | | | | | | | |
| | Year x Season x Sex | 6 | 435 | 0.54 | 709 | 0.68 | 209 | 0.31 | | | | | | | |
| | Explained | 23 | 74810 | 24.84$^a$ | 60106 | 15.05$^a$ | 11150 | 4.28$^a$ | | | | | | | |
| | Residual | 985 | 129065 | | 171157 | | 111632 | | | | | | | | |
| | Total | 1008 | 203955 | | 231323 | | 122796 | | | | | | | | |
| AGE = 3 | | | | | | | | | | | | | | | |
| Main Effects: | Year | 3 | 11720 | 23.96$^a$ | 13800 | 25.67$^a$ | 8562 | 29.30$^a$ | 3 | 1842 | 2.36 | 2120 | 2.72$^d$ | 1609 | 8.19$^a$ |
| | Season | 2 | 54916 | 165.09$^a$ | 130766 | 378.46$^a$ | 2697 | 13.83$^a$ | 2 | 13142 | 24.58$^a$ | 4452 | 8.57$^b$ | 615 | 4.06$^c$ |
| | Sex | 1 | 38762 | 232.96$^a$ | 27535 | 130.50$^a$ | 35292 | 362.33$^a$ | 1 | 1394 | 5.23$^d$ | 589 | 2.25 | 292 | 4.75$^d$ |
| | Year x Season | 6 | 10941 | 10.96$^a$ | 7772 | 7.07$^a$ | 2836 | 4.50$^b$ | 6 | 1464 | 0.91 | 1486 | 0.95 | 1339 | 3.23$^c$ |
| | Year x Sex | 3 | 71 | 0.14 | 232 | 0.42 | 351 | 1.20 | 3 | 537 | 0.66 | 520 | 0.66 | 125 | 0.61 |
| | Season x Sex | 2 | 10114 | 30.40$^a$ | 2276 | 6.62$^b$ | 52 | 0.27 | 2 | 187 | 0.35 | 231 | 0.44 | 158 | 1.15 |
| | Year x Season x Sex | 6 | 975 | 0.98 | 999 | 0.96 | 1314 | 2.25$^d$ | 5 | 617 | 0.46 | 679 | 0.52 | 600 | 1.76 |
| | Explained | 23 | 190060 | 49.72$^a$ | 305116 | 71.83$^a$ | 86366 | 38.59$^a$ | 27 | 70682 | 12.85$^a$ | 17843 | 3.11$^a$ | 5493 | 3.63$^a$ |
| | Residual | 2732 | 454177 | | 471676 | | 266126 | | 584 | 156130 | | 152067 | | 40121 | |
| | Total | 2755 | 644537 | | 754582 | | 352494 | | 606 | 226813 | | 170300 | | 45614 | |
| AGE = 4 | | | | | | | | | | | | | | | |
| Main Effects: | Year | 3 | 6565 | 5.99$^b$ | 8807 | 7.72$^a$ | 444 | 2.99$^d$ | 3 | 20160 | 43.54$^a$ | 30318 | 64.50$^a$ | 1162 | 5.06$^b$ |
| | Season | 2 | 16776 | 22.82$^a$ | 41051 | 57.32$^a$ | 1422 | 12.43$^a$ | 2 | 15492 | 35.94$^a$ | 20512 | 65.30$^a$ | 1072 | 8.06$^b$ |
| | Sex | 1 | 50606 | 137.96$^a$ | 63164 | 170.40$^a$ | 3766 | 66.22$^a$ | 1 | 7507 | 34.83$^a$ | 5064 | 24.96$^a$ | 960 | 14.17$^a$ |
| | Year x Season | 6 | 5362 | 2.35$^d$ | 3621 | 1.09 | 605 | 2.50$^d$ | 6 | 4006 | 3.09$^c$ | 3277 | 2.40$^d$ | 1036 | 2.66$^d$ |
| | Year x Sex | 3 | 1463 | 1.33 | 2003 | 1.94 | 92 | 0.56 | 3 | 263 | 0.41 | 32 | 0.05 | 16 | 0.37 |
| | Season x Sex | 2 | 1381 | 1.88 | 2281 | 3.10$^d$ | 1186 | 10.47$^a$ | 2 | 1960 | 6.57$^b$ | 1630 | 3.62$^d$ | 437 | 3.25$^d$ |
| | Year x Season x Sex | 6 | 1368 | 0.61 | 1487 | 0.69 | 525 | 1.52 | 6 | 2911 | 2.25$^d$ | 2426 | 1.78 | 1621 | 4.07$^b$ |
| | Explained | 23 | 235266 | 27.84$^a$ | 293261 | 35.67$^a$ | 27197 | 20.76$^a$ | 27 | 150933 | 32.26$^a$ | 100615 | 20.76$^a$ | 12736 | 8.36$^a$ |
| | Residual | 931 | 342065 | | 333462 | | 53193 | | 1463 | 315336 | | 332260 | | 97076 | |
| | Total | 954 | 577330 | | 626794 | | 80389 | | 1490 | 475260 | | 448876 | | 109812 | |
| AGE = 5 | | | | | | | | | | | | | | | |
| Main Effects: | Year | 3 | 6193 | 2.85$^d$ | 6934 | 3.17$^d$ | 99 | 0.59 | 3 | 3654 | 5.97$^b$ | 2634 | 4.53$^c$ | 4832 | 21.67$^a$ |
| | Season | 2 | 779 | 0.56 | 1065 | 1.24 | 65 | 0.61 | 2 | 15984 | 38.78$^a$ | 4560 | 10.93$^a$ | 1898 | 8.79$^b$ |
| | Sex | 1 | 42466 | 58.59$^a$ | 36724 | 69.79$^a$ | 1207 | 21.53$^a$ | 1 | 12734 | 62.13$^a$ | 13612 | 65.12$^a$ | 765 | 11.97$^b$ |
| | Year x Season | 5 | 938 | 0.26 | 1063 | 0.29 | 156 | 0.56 | 6 | 2990 | 2.44$^d$ | 3356 | 2.67$^c$ | 1092 | 2.03$^c$ |
| | Year x Sex | 3 | 1973 | 0.91 | 2630 | 1.19 | 37 | 0.22 | 3 | 1154 | 1.86 | 1229 | 1.95 | 142 | 0.76 |
| | Season x Sex | 2 | 1450 | 1.06 | 869 | 0.56 | 30 | 0.16 | 2 | 119 | 0.20 | 235 | 0.56 | 193 | 1.55 |
| | Year x Season x Sex | 3 | 1422 | 0.65 | 1509 | 0.64 | 26 | 1.55 | 6 | 2636 | 2.16$^d$ | 2626 | 1.95 | 369 | 0.65 |
| | Explained | 19 | 193511 | 14.08$^a$ | 196704 | 14.07$^a$ | 5778 | 5.43$^a$ | 23 | 58965 | 12.50$^a$ | 51005 | 10.78$^a$ | 35814 | 10.32$^a$ |
| | Residual | 164 | 118876 | | 121070 | | 9186 | | 1125 | 230660 | | 235151 | | 65860 | |
| | Total | 183 | 312781 | | 317830 | | 10950 | | 1148 | 289635 | | 286956 | | 84853 | |
| AGE = 6 | | | | | | | | | | | | | | | |
| Main Effects: | Year | 3 | 437 | 0.15 | 456 | 0.32 | 19 | 0.15 | 3 | 10159 | 35.46$^a$ | 10870 | 22.37$^a$ | 783 | 7.03$^b$ |
| | Season | 2 | 303 | 0.11 | 127 | 0.17 | 61 | 0.48 | 2 | 3321 | 10.92$^a$ | 115 | 0.38 | 112 | 1.49 |
| | Sex | 1 | 10469 | 11.4$^a$ | 13951 | 20.34$^a$ | 119 | 2.72 | 1 | 8617 | 56.62$^a$ | 7195 | 47.02$^a$ | 16 | 0.42 |
| | Year x Season | 3 | 3701 | 2.05 | 3819 | 2.04$^d$ | 203 | 2.23 | 6 | 3965 | 4.36$^b$ | 2800 | 3.05$^c$ | 1790 | 7.96$^a$ |
| | Year x Sex | 2 | 956 | 1.02 | 625 | 0.66 | 164 | 2.06 | 3 | 76 | 1.71 | 696 | 1.51 | 256 | 2.27 |
| | Season x Sex | 1 | 81 | 0.17 | 138 | 0.25 | 8 | 0.20 | 2 | 102 | 0.35 | 295 | 0.96 | 525 | 6.97$^b$ |
| | Year x Season x Sex | 1 | 2529 | 5.47$^d$ | 1822 | 4.07$^d$ | 30 | 0.74 | 6 | 2049 | 2.24$^d$ | 1602 | 1.74 | 882 | 3.35$^b$ |
| | Explained | 13 | 29611 | 4.08$^a$ | 30884 | 5.03$^a$ | 1078 | 1.96$^d$ | 23 | 77081 | 22.38$^a$ | 60853 | 17.23$^a$ | 9766 | 6.66$^a$ |
| | Residual | 84 | 39139 | | 39673 | | 3556 | | 929 | 141317 | | 142162 | | 34943 | |
| | Total | 97 | 68551 | | 70557 | | 4629 | | 952 | 219396 | | 202814 | | 44667 | |
| AGE = 7 | | | | | | | | | | | | | | | |
| Main Effects: | Year | | | | | | | | 3 | 33[illegible] | 0.37 | 541 | 0.87 | 71 | 1.10 |
| | Season | | | | | | | | 2 | 731 | 1.7[illegible]$^b$ | 37 | 0.09 | 76 | 1.70 |
| | Sex | | | | | | | | 1 | 2606 | 12.99$^a$ | 2910 | 14.06$^b$ | 26 | 1.16 |
| | Year x Season | | | | | | | | 6 | 1469 | 1.10 | 1240 | 1.00 | 212 | 1.65 |
| | Year x Sex | | | | | | | | 3 | 1153 | 1.05 | 826 | 1.33 | 91 | 0.70 |
| | Season x Sex | | | | | | | | 2 | 304 | 0.93 | 326 | 0.70 | 143 | 3.34$^d$ |
| | Year x Season x Sex | | | | | | | | 4 | 1768 | 2.10 | 1503 | 1.81 | 152 | 1.75 |
| | Explained | | | | | | | | 21 | 27152 | 6.23$^a$ | 25070 | 5.77$^a$ | 1036 | 2.31$^b$ |
| | Residual | | | | | | | | 367 | 72064 | | 71835 | | 7408 | |
| | Total | | | | | | | | 388 | 99196 | | 96904 | | 8444 | |

$^a$ significant at P < 0.0001
$^b$ significant at P < 0.001
$^c$ significant at P < 0.01
$^d$ significant at P < 0.05

Table 4.3-13. Analyses of variance testing the effects of year, season and sex on age specific fork lengths at capture, backcalculated fork lengths at last annulus and last increments of growth for smallmouth bass captured at standard Nanticoke locations, Long Point Bay, Lake Erie (1980-1983).

| SOURCE OF VARIATION | FORK LENGTH AT CAPTURE | | | | | FORK LENGTH AT LAST ANNULUS | | | | | LAST INCREMENT OF GROWTH | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | df | SS | MS | F | P | df | SS | MS | F | P | df | SS | MS | F | P |
| AGE = 2 | | | | | | | | | | | | | | | |
| Main Effects: Year | 3 | 3769.0 | 1256.3 | 2.57 | 0.0609 | 3 | 5530.5 | 1843.5 | 5.83 | 0.0015 | 3 | 3765.1 | 1225.0 | 8.28 | 0.0001 |
| Season | 1 | 6501.2 | 6501.2 | 13.28 | 0.0005 | 1 | 96.2 | 96.2 | 0.30 | 0.5829 | 1 | 114.2 | 114.2 | 0.75 | 0.3886 |
| Sex | 1 | 15.7 | 15.7 | 0.03 | 0.8586 | 1 | 62.6 | 62.6 | 0.20 | 0.6576 | 1 | 7.2 | 7.2 | 0.05 | 0.8282 |
| Year x Season | 3 | 1145.1 | 381.7 | 0.78 | 0.5124 | 3 | 1725.6 | 575.2 | 1.82 | 0.1505 | 3 | 777.5 | 259.2 | 1.71 | 0.1719 |
| Year x Sex | 3 | 2216.6 | 738.9 | 1.51 | 0.2190 | 3 | 936.2 | 312.1 | 0.99 | 0.4055 | 3 | 1705.6 | 568.5 | 3.75 | 0.0149 |
| Season x Sex | 1 | 297.7 | 297.7 | 0.61 | 0.4383 | 1 | 255.6 | 255.6 | 0.81 | 0.3717 | 1 | 167.4 | 167.4 | 1.10 | 0.2971 |
| Year x Season x Sex | 2 | 202.2 | 101.1 | 0.21 | 0.8139 | 2 | 623.6 | 311.8 | 0.99 | 0.3783 | 2 | 705.2 | 352.6 | 2.33 | 0.1056 |
| Explained | 14 | 43135.2 | 3081.1 | 6.29 | 0.0001 | 14 | 18902.8 | 1350.2 | 4.27 | 0.0001 | 14 | 12582.1 | 898.7 | 5.93 | 0.0001 |
| Residual | 66 | 32308.8 | 489.5 | | | 66 | 20857.0 | 316.0 | | | 66 | 10002.1 | 151.6 | | |
| Total | 80 | 75444.0 | | | | 80 | 39759.8 | | | | 80 | 22584.2 | | | |
| AGE = 3 | | | | | | | | | | | | | | | |
| Main Effects: Year | 3 | 1420.4 | 473.5 | 0.43 | 0.7323 | 3 | 1700.3 | 566.8 | 0.67 | 0.5787 | 3 | 2529.2 | 843.1 | 5.19 | 0.0022 |
| Season | 2 | 13290.2 | 6645.1 | 6.10 | 0.0029 | 2 | 3118.0 | 1559.0 | 1.83 | 0.1646 | 2 | 85.9 | 43.0 | 0.26 | 0.7679 |
| Sex | 1 | 136.9 | 136.9 | 0.13 | 0.7236 | 1 | 1.5 | 1.5 | 0.00 | 0.9666 | 1 | 33.5 | 33.5 | 0.21 | 0.6502 |
| Year x Season | 3 | 1186.5 | 395.5 | 0.36 | 0.7826 | 3 | 134.0 | 44.7 | 0.05 | 0.9786 | 3 | 24.9 | 8.3 | 0.05 | 0.9792 |
| Year x Sex | 2 | 1209.1 | 604.6 | 0.55 | 0.5755 | 2 | 2078.8 | 1039.4 | 1.22 | 0.2986 | 2 | 583.1 | 291.6 | 1.80 | 0.1699 |
| Season x Sex | 2 | 79.8 | 39.9 | 0.04 | 0.9641 | 2 | 205.4 | 102.7 | 0.12 | 0.8866 | 2 | 559.4 | 279.7 | 1.72 | 0.1825 |
| Year x Season x Sex | 1 | 1613.1 | 1613.1 | 1.48 | 0.2259 | 1 | 1179.0 | 1179.0 | 1.38 | 0.2416 | 1 | 102.4 | 102.4 | 0.63 | 0.4284 |
| Explained | 15 | 45498.2 | 3033.2 | 2.78 | 0.0009 | 15 | 50330.0 | 3355.3 | 3.94 | 0.0001 | 15 | 4451.7 | 296.8 | 1.83 | 0.0367 |
| Residual | 132 | 143839.4 | 1089.7 | | | 132 | 112491.8 | 852.2 | | | 132 | 21422.0 | 162.3 | | |
| Total | 147 | 189337.7 | | | | 147 | 162821.8 | | | | 147 | 25873.6 | | | |
| AGE = 4 | | | | | | | | | | | | | | | |
| Main Effects: Year | 3 | 10387.6 | 3462.5 | 4.82 | 0.0045 | 3 | 12411.9 | 4137.3 | 6.22 | 0.0010 | 3 | 2076.2 | 692.1 | 6.15 | 0.0010 |
| Season | 2 | 11744.7 | 5872.4 | 8.17 | 0.0007 | 2 | 428.6 | 214.3 | 0.32 | 0.7256 | 2 | 246.8 | 123.4 | 1.10 | 0.3401 |
| Sex | 1 | 442.3 | 442.3 | 0.62 | 0.4356 | 1 | 367.3 | 367.3 | 0.55 | 0.4606 | 1 | 33.1 | 33.1 | 0.29 | 0.5892 |
| Year x Season | 3 | 1612.5 | 537.5 | 0.75 | 0.5306 | 3 | 1132.3 | 377.4 | 0.57 | 0.6422 | 3 | 108.5 | 36.2 | 0.32 | 0.8118 |
| Year x Sex | 2 | 883.4 | 441.7 | 0.61 | 0.5439 | 2 | 545.6 | 272.8 | 0.41 | 0.6651 | 2 | 377.6 | 188.8 | 1.68 | 0.1948 |
| Season x Sex | 2 | 2107.4 | 1053.7 | 1.47 | 0.2383 | 2 | 1936.9 | 968.5 | 1.46 | 0.2405 | 2 | 593.8 | 296.9 | 2.64 | 0.0791 |
| Year x Season x Sex | 2 | 818.4 | 414.2 | 0.57 | 0.5686 | 2 | 443.0 | 221.5 | 0.33 | 0.7179 | 2 | 283.9 | 142.0 | 1.26 | 0.2901 |
| Explained | 15 | 44092.1 | 2939.5 | 4.09 | 0.0001 | 15 | 31745.7 | 2116.4 | 3.18 | 0.0006 | 15 | 5519.5 | 368.0 | 3.27 | 0.0005 |
| Residual | 65 | 46711.4 | 718.6 | | | 65 | 43210.5 | 664.8 | | | 65 | 7314.6 | 112.5 | | |
| Total | 80 | 90803.5 | | | | 80 | 74956.2 | | | | 80 | 12834.1 | | | |

Table 4.3-14. Seasonal trends in age-specific least suares mean fork lengths at capture (mm) backcalculated fork lengths at last annulus (mm) and last increments of growth (mm) for yellow perch and rock bass captured at standard Nanticoke locations, Long Point Bay, Lake Erie (1980-1983). Years pooled.

| | | AGE II | | | | | | AGE III | | | | | | AGE IV | | | | | | AGE V | | | | | | AGE VI | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fork Length at Capture | | Fork Length at Last Annulus | | Last Increment of Growth | | Fork Length at Capture | | Fork Length at Last Annulus | | Last Increment of Growth | | Fork Length at Capture | | Fork Length at Last Annulus | | Last Increment of Growth | | Fork Length at Capture | | Fork Length at Last Annulus | | Last Increment of Growth | | Fork Length at Capture | | Fork Length at Last Annulus | | Last Increment of Growth | |
| Sex | Season | Least Squares Mean | Std. Error | Least Squares Mean | Std. Error | Least Squares Mean | Std. Error | Least Squares Mean | Std. Error | Least Squares Mean | Std. Error | Least Squares Mean | Std. Error | Least Squares Mean | Std. Error | Least Squares Mean | Std. Error | Least Squares Mean | Std. Error | Least Squares Mean | Std. Error | Least Squares Mean | Std. Error | Least Squares Mean | Std. Error | Least Squares Mean | Std. Error | Least Squares Mean | Std. Error | Least Squares Mean | Std. Error |
| | | | | | | | | | | | | | | YELLOW PERCH | | | | | | | | | | | | | | | | | |
| Male | Spring | 170.8 | 3.74 | 162.1 | 0.61 | 74.1 | 2.65 | 182.1 | 0.84 | [illegible] | 0.67 | 62.9 | 0.51 | [illegible] | 1.14 | [illegible] | 1.42 | 24.2 | 0.61 | 213.9 | 4.67 | 232.7 | 4.40 | 16.7 | 1.32 | | | | | | |
| | Summer | 170.4 | 2.67 | 164.8 | 3.08 | 61.0 | 2.49 | 178.7 | 0.84 | 163.8 | 0.86 | 39.6 | 0.44 | 183.7 | [illegible] | 173.7 | 1.64 | [illegible] | 0.67 | 188.2 | | 184.0 | | 17.8 | | | | | | | |
| | Fall | 177.4 | 1.27 | 137.8 | 1.46 | 58.0 | 1.18 | 188.9 | 1.30 | 163.1 | 1.01 | 62.1 | [illegible] | [illegible] | 2.61 | 184.9 | 2.06 | 25.8 | 1.16 | 211.7 | | 199.5 | | 19.8 | | | | | | | |
| Female | Spring | 166.0 | 2.76 | 162.7 | 3.21 | 70.1 | 2.52 | [illegible] | 0.47 | 166.4 | 0.41 | 53.1 | 0.36 | 219.4 | 1.10 | 217.4 | 1.30 | 30.6 | 0.46 | [illegible] | 2.95 | 267.4 | 2.98 | [illegible] | 0.82 | | | | | | |
| | Summer | 176.5 | 1.67 | 162.2 | 1.70 | 60.6 | 1.37 | 185.8 | [illegible] | 163.8 | 0.76 | 69.1 | 0.59 | 203.4 | 1.77 | [illegible] | 3.18 | 27.1 | 1.31 | 268.4 | | 255.6 | | 25.2 | | | | | | | |
| | Fall | 195.2 | 0.59 | 138.7 | 0.88 | 61.3 | 0.51 | 205.7 | 0.86 | 176.1 | 0.81 | 58.9 | 0.62 | 226.1 | 3.67 | 204.6 | 3.53 | 32.1 | 1.62 | 272.2 | | 254.5 | 12.19 | [illegible] | 3.33 | | | | | | |
| Combined | Spring | 168.6 | 2.31 | 162.6 | 2.04 | 72.1 | 2.21 | 186.9 | 0.61 | 164.0 | 0.41 | 67.2 | 0.31 | 204.0 | 0.61 | 223.0 | 0.81 | 29.4 | 0.32 | 241.2 | 2.65 | 240.1 | 2.67 | 21.9 | 0.74 | | | | | | |
| | Summer | 172.5 | 1.51 | 163.5 | 1.76 | 61.1 | 1.42 | 182.6 | 0.57 | 166.0 | 0.38 | 66.4 | 0.46 | 191.6 | 1.04 | [illegible] | 1.06 | 25.6 | 1.74 | 228.3 | | 219.6 | | 21.5 | | | | | | | |
| | Fall | 183.9 | 0.64 | 138.1 | 0.81 | 60.0 | 0.61 | 197.7 | 0.64 | 168.0 | 0.61 | 66.9 | 0.49 | 213.2 | 2.31 | 191.6 | 2.32 | 29.0 | 3.93 | 243.6 | | 227.0 | | 26.3 | | | | | | | |
| | | | | | | | | | | | | | | ROCK BASS | | | | | | | | | | | | | | | | | |
| Male | Spring | | | | | | | 151.9 | | 169.7 | | 66.9 | | 187.0 | 1.14 | 186.6 | 1.17 | 42.9 | 0.63 | 200.8 | 0.92 | 207.6 | 0.92 | 31.8 | 0.50 | 232.9 | 0.91 | 230.7 | 0.92 | 19.1 | 0.45 |
| | Summer | | | | | | | [illegible] | 2.37 | 175.6 | 2.10 | [illegible] | [illegible] | 188.6 | [illegible] | 169.9 | 1.41 | 36.4 | 0.74 | 210.9 | 1.48 | 201.1 | 1.70 | 32.2 | 0.93 | 235.9 | 2.37 | 229.1 | 2.37 | 16.4 | 1.18 |
| | Fall | | | | | | | 174.6 | 2.34 | 177.6 | 2.14 | 65.9 | 1.10 | [illegible] | [illegible] | 169.2 | 1.30 | 37.9 | 0.76 | 221.1 | 1.38 | 203.0 | 1.46 | 33.7 | 0.76 | 238.9 | 1.75 | 226.3 | 1.76 | 21.8 | 0.47 |
| Female | Spring | | | | | | | [illegible] | [illegible] | [illegible] | 3.66 | 69.6 | 1.96 | [illegible] | [illegible] | 174.6 | 1.44 | 37.9 | 0.79 | 199.3 | 1.09 | 197.8 | 1.10 | 28.1 | 0.60 | 217.5 | 1.23 | 216.4 | 1.34 | 17.3 | 0.42 |
| | Summer | | | | | | | 150.6 | 3.26 | [illegible] | 3.27 | [illegible] | [illegible] | 181.3 | 1.96 | [illegible] | 1.84 | 38.1 | 0.95 | 202.5 | 1.83 | 182.0 | 1.05 | 30.2 | 1.01 | 221.6 | 1.81 | 217.5 | 1.82 | 20.3 | 0.90 |
| | Fall | | | | | | | 167.3 | 3.36 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 163.9 | 2.16 | 36.3 | 1.14 | 210.4 | 1.83 | 182.2 | 1.83 | 32.4 | 1.00 | 227.1 | 1.43 | 217.2 | 1.44 | 22.8 | 0.67 |
| Combined | Spring | | | | | | | [illegible] | | 167.8 | | [illegible] | | [illegible] | [illegible] | 179.6 | 0.94 | 40.6 | 0.91 | 204.6 | 0.71 | [illegible] | 0.72 | 29.9 | 0.39 | 224.7 | 0.77 | 223.6 | 0.77 | 18.2 | 0.38 |
| | Summer | | | | | | | 152.1 | 1.88 | 164.5 | 1.97 | [illegible] | 1.06 | [illegible] | 1.13 | 168.2 | 1.16 | 38.7 | 0.63 | 206.7 | 1.24 | 197.0 | 1.23 | 31.2 | 0.68 | [illegible] | 1.49 | 221.1 | 1.50 | 18.3 | 0.74 |
| | Fall | | | | | | | 170.6 | 2.08 | 164.6 | 1.97 | 65.1 | 1.07 | [illegible] | [illegible] | 166.5 | 1.24 | 37.1 | 0.67 | 215.8 | 1.14 | 190.1 | 1.15 | 33.0 | 0.63 | 233.0 | 1.93 | 221.8 | 1.93 | 20.8 | 0.46 |

Table 4.3-15. One-way analyses of variance testing the effect of year on age specific empirical fork lengths, backcalculated fork lengths at last annulus and last increments of growth for yellow perch (1971-1983) and rock bass (1974-1983) captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie. Sexes and locations pooled.

| | | YELLOW PERCH | | | | | | | | | ROCK BASS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Empirical Fork Length at Capture (spring) | | | Fork Length at Last Annulus | | | Last Increment of Growth | | | Empirical Fork Length at Capture (spring) | | | Fork Length at Last Annulus | | | Last Increment of Growth | | |
| Source of Variation | | df | SS | F | df | SS | F | df | SS | F | df | SS | F | df | SS | F | df | SS | F |
| **AGE = 2** | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Year | 11 | 25888 | $10.23^a$ | 11 | 114385 | $46.27^a$ | 11 | 5965 | $4.28^a$ | | | | | | | | | |
| | Residual | 170 | 39121 | | 1633 | 366982 | | 1633 | 207104 | | | | | | | | | | |
| | Total | 181 | 65008 | | 1644 | 481377 | | 1644 | 213069 | | | | | | | | | | |
| **AGE = 3** | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Year | 11 | 51051 | $22.83^a$ | 11 | 121958 | $41.64^a$ | 11 | 37137 | $26.89^a$ | 6 | 1357 | 3.33 | 8 | 5205 | $2.36^d$ | 8 | 2833 | $4.65^a$ |
| | Residual | 2484 | 505010 | | 4208 | 1120534 | | 4208 | 528251 | | 77 | 12501 | | 757 | 208762 | | 757 | 57608 | |
| | Total | 2495 | 556061 | | 4219 | 1242491 | | 4219 | 565389 | | 83 | 13858 | | 765 | 213966 | | 765 | 60441 | |
| **AGE = 4** | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Year | 11 | 75867 | $10.63^a$ | 11 | 130658 | $18.44^a$ | 11 | 5308 | $5.10^a$ | 8 | 17858 | $7.76^a$ | 8 | 36801 | $15.06^a$ | 8 | 5200 | $4.93^a$ |
| | Residual | 1215 | 788095 | | 1719 | 1107419 | | 1719 | 162670 | | 369 | 278849 | | 2177 | 464892 | | 2177 | 158306 | |
| | Total | 1226 | 863962 | | 1730 | 1238077 | | 1730 | 167977 | | 377 | 296707 | | 2185 | 501693 | | 2185 | 163505 | |
| **AGE = 5** | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Year | 11 | 50670 | $1.95^a$ | 11 | 65737 | $3.00^d$ | 11 | 1486 | $1.89^d$ | 8 | 9147 | $5.51^a$ | 8 | 9920 | $5.42^a$ | 8 | 15791 | $28.83^a$ |
| | Residual | 342 | 398515 | | 402 | 480696 | | 402 | 28657 | | 1439 | 298760 | | 2013 | 460450 | | 2013 | 137843 | |
| | Total | 353 | 449185 | | 413 | 546433 | | 413 | 30142 | | 1447 | 307906 | | 2021 | 470370 | | 2021 | 153634 | |
| **AGE = 6** | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Year | 11 | 18445 | $2.63^c$ | 11 | 17580 | $2.51^c$ | 11 | 1965 | $4.84^a$ | 8 | 25292 | $15.30^a$ | 8 | 27596 | $16.71^a$ | 8 | 2035 | $5.44^a$ |
| | Residual | 198 | 126034 | | 231 | 146926 | | 231 | 8526 | | 1141 | 235757 | | 1583 | 326717 | | 1583 | 74071 | |
| | Total | 209 | 144479 | | 242 | 164506 | | 242 | 10491 | | 1149 | 261048 | | 1591 | 354313 | | 1591 | 76106 | |
| **AGE = 7** | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Year | 11 | 9520 | $1.80^d$ | 11 | 9951 | $1.98^d$ | 11 | 358 | $1.85^d$ | 8 | 3723 | $4.61^a$ | 8 | 10262 | $4.40^a$ | 8 | 608 | $2.03^d$ |
| | Residual | 145 | 69679 | | 165 | 75237 | | 165 | 2895 | | 488 | 126589 | | 628 | 182885 | | 628 | 23541 | |
| | Total | 156 | 79199 | | 176 | 85188 | | 176 | 3253 | | 496 | 130312 | | 636 | 193147 | | 636 | 24149 | |
| **AGE = 8** | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Year | 10 | 3530 | 1.19 | 10 | 3438 | 1.15 | 10 | 171 | 1.36 | 8 | 6127 | $3.07^c$ | 8 | 5497 | $2.70^c$ | 8 | 734 | $2.02^d$ |
| | Residual | 107 | 31724 | | 114 | 34084 | | 114 | 1431 | | 168 | 31955 | | 466 | 118399 | | 466 | 21182 | |
| | Total | 117 | 35254 | | 124 | 37522 | | 124 | 1603 | | 176 | 38082 | | 474 | 123896 | | 474 | 21916 | |
| **AGE = 9** | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Year | | | | | | | | | | 7 | 4831 | $3.34^c$ | 8 | 7157 | $3.52^b$ | 8 | 162 | $2.16^d$ |
| | Residual | | | | | | | | | | 71 | 14660 | | 245 | 62206 | | 245 | 2295 | |
| | Total | | | | | | | | | | 78 | 19491 | | 253 | 69363 | | 253 | 2457 | |

[a] significant at $P = 0.0001$
[b] significant at $P < 0.001$
[c] significant at $P < 0.01$
[d] significant at $P < 0.05$

Table 4.3-16. One-way analyses of variance testing the effect of year on age specific empirical fork lengths at last annulus and last increments of growth for smallmouth bass (1972-1983) and white bass (1971-1983) captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie. Sexes and locations pooled.

| | SMALLMOUTH BASS | | | | | | | | | WHITE BASS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Empirical Fork Length at Capture (spring) | | | Fork Length at Last Annulus | | | Last Increment of Growth | | | Empirical Fork Length at Capture (spring) | | | Fork Length at Last Annulus | | | Last Increment of Growth | | |
| Source of Variation | df | SS | F | df | SS | F | df | SS | F | df | SS | F | df | SS | F | df | SS | F |
| **AGE = 1** | | | | | | | | | | | | | | | | | | |
| Main Effect: Year | | | | | | | | | | 8 | 19999 | 14.23[a] | 11 | 62180 | 27.09[a] | | | |
| Residual | | | | | | | | | | 260 | 45669 | | 1508 | 314665 | | | | |
| Total | | | | | | | | | | 268 | 65667 | | 1519 | 376845 | | | | |
| **AGE = 2** | | | | | | | | | | | | | | | | | | |
| Main Effect: Year | | | | 10 | 30378 | 13.41[a] | 10 | 28667 | 21.11[a] | 11 | 24959 | 5.52[a] | 11 | 50766 | 11.23[a] | 11 | 28606 | 10.65[a] |
| Residual | | | | 261 | 59132 | | 261 | 35443 | | 158 | 64950 | | 292 | 120042 | | 292 | 71319 | |
| Total | | | | 271 | 89510 | | 271 | 64110 | | 169 | 89909 | | 303 | 170808 | | 303 | 99925 | |
| **AGE = 3** | | | | | | | | | | | | | | | | | | |
| Main Effect: Year | 8 | 9021 | 3.63[b] | 10 | 45642 | 11.68[a] | 10 | 33338 | 31.28[a] | | | | | | | | | |
| Residual | 78 | 24261 | | 480 | 187539 | | 480 | 51158 | | | | | | | | | | |
| Total | 86 | 33281 | | 490 | 233181 | | 490 | 84496 | | | | | | | | | | |
| **AGE = 4** | | | | | | | | | | | | | | | | | | |
| Main Effect: Year | 9 | 24323 | 8.37[a] | 10 | 60029 | 9.46[a] | 10 | 15756 | 14.85[a] | | | | | | | | | |
| Residual | 158 | 51005 | | 299 | 189654 | | 299 | 31719 | | | | | | | | | | |
| Total | 167 | 75328 | | 309 | 249682 | | 309 | 47475 | | | | | | | | | | |
| **AGE = 5** | | | | | | | | | | | | | | | | | | |
| Main Effect: Year | 10 | 19290 | 5.28[a] | 10 | 24955 | 6.08[a] | 10 | 4877 | 4.28[a] | | | | | | | | | |
| Residual | 115 | 42029 | | 162 | 66546 | | 162 | 18462 | | | | | | | | | | |
| Total | 125 | 61319 | | 172 | 91501 | | 172 | 23339 | | | | | | | | | | |
| **AGE = 6** | | | | | | | | | | | | | | | | | | |
| Main Effect: Year | 7 | 13079 | 4.31[c] | 10 | 16424 | 3.16[c] | 10 | 1212 | 1.41 | | | | | | | | | |
| Residual | 31 | 13440 | | 40 | 20763 | | 40 | 3428 | | | | | | | | | | |
| Total | 38 | 26520 | | 50 | 37187 | | 50 | 4640 | | | | | | | | | | |

[a] significant at $P = 0.0001$

[b] significant at $P < 0.001$

[c] significant at $P < 0.01$

[d] significant at $P < 0.05$

Table 4.3-17. One-way analyses of variance testing the effect of period (baseline, commissioning and operational) on age specific backcalculated fork lengths at last annulus and last increments of growth for yellow perch, rock bass (commissioning *vs* operational only), smallmouth bass and white bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie. Sexes and locations pooled.

| | | YELLOW PERCH | | | | | | ROCK BASS | | | | | | SMALLMOUTH BASS | | | | | | WHITE BASS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fork Length at Last Annulus | | | Last Increment of Growth | | | Fork Length at Last Annulus | | | Last Increment of Growth | | | Fork Length at Last Annulus | | | Last Increment of Growth | | | Fork Length at Last Annulus | | | Last Increment of Growth | | |
| Source of Variation | | df | SS | F | df | SS | F | df | SS | F | df | SS | F | df | SS | F | df | SS | F | df | SS | F | df | SS | F |
| AGE = 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Period | | | | | | | | | | | | | | | | | | | 2 | 39063 | 87.72$^{a}$ | | | |
| | Residual | | | | | | | | | | | | | | | | | | | 1517 | 337781 | | | | |
| | Total | | | | | | | | | | | | | | | | | | | 1519 | 376845 | | | | |
| AGE = 2 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Period | 2 | 61925 | 119.79$^{a}$ | 2 | 1098 | 4.25$^{c}$ | | | | | | | 2 | 9001 | 15.04$^{a}$ | 2 | 14294 | 38.59$^{a}$ | 2 | 15755 | 15.29$^{a}$ | 2 | 6061 | 9.72$^{a}$ |
| | Residual | 1642 | 620082 | | 1642 | 211971 | | | | | | | | 269 | 40509 | | 269 | 49816 | | 301 | 155053 | | 301 | 93864 | |
| | Total | 1644 | 681377 | | 1644 | 213069 | | | | | | | | 271 | 49510 | | 271 | 64110 | | 303 | 170808 | | 303 | 99925 | |
| AGE = 3 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Period | 2 | 80721 | 146.50$^{a}$ | 2 | 9318 | 35.33$^{a}$ | 1 | 1983 | 7.15$^{c}$ | 1 | 114 | 1.44 | 2 | 6569 | 7.07$^{b}$ | 2 | 18611 | 68.92$^{a}$ | | | | | | |
| | Residual | 4217 | 1161772 | | 4217 | 556071 | | 764 | 211983 | | 764 | 60327 | | 488 | 226612 | | 488 | 65885 | | | | | | | |
| | Total | 4219 | 1242493 | | 4219 | 565389 | | 765 | 213966 | | 765 | 60441 | | 490 | 233181 | | 490 | 84496 | | | | | | | |
| AGE = 4 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Period | 2 | 90518 | 68.15$^{a}$ | 2 | 817 | 4.22$^{c}$ | 1 | 955 | 2.97 | 1 | 88 | 1.18 | 2 | 24608 | 16.78$^{a}$ | 2 | 8004 | 31.13$^{a}$ | | | | | | |
| | Residual | 1728 | 1147559 | | 1728 | 167160 | | 2184 | 700738 | | 2184 | 163497 | | 307 | 225074 | | 307 | 39471 | | | | | | | |
| | Total | 1730 | 1238077 | | 1730 | 167977 | | 2185 | 701693 | | 2185 | 163585 | | 309 | 249682 | | 309 | 47475 | | | | | | | |
| AGE = 5 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Period | 2 | 14264 | 5.51$^{c}$ | 2 | 5 | 0.04 | 1 | 6742 | 29.37$^{a}$ | 1 | 3644 | 49.07$^{a}$ | 2 | 12903 | 13.95$^{a}$ | 2 | 2495 | 10.17$^{a}$ | | | | | | |
| | Residual | 411 | 532170 | | 411 | 30137 | | 2020 | 663628 | | 2020 | 149990 | | 170 | 78598 | | 170 | 20844 | | | | | | | |
| | Total | 413 | 546433 | | 413 | 30142 | | 2021 | 670370 | | 2021 | 153634 | | 172 | 91501 | | 172 | 23339 | | | | | | | |
| AGE = 6 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Period | 2 | 2451 | 1.81 | 2 | 430 | 5.13$^{c}$ | 1 | 6456 | 29.51$^{a}$ | 1 | 58 | 1.20 | 2 | 10140 | 9.00$^{b}$ | 2 | 328 | 1.82 | | | | | | |
| | Residual | 240 | 162056 | | 240 | 10061 | | 1590 | 347857 | | 1590 | 76049 | | 48 | 27047 | | 48 | 4312 | | | | | | | |
| | Total | 242 | 164506 | | 242 | 10491 | | 1591 | 354313 | | 1591 | 76106 | | 50 | 37187 | | 50 | 4640 | | | | | | | |
| AGE = 7 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Period | | | | | | | 1 | 5044 | 17.03$^{a}$ | 1 | 51 | 1.33 | | | | | | | | | | | | |
| | Residual | | | | | | | 635 | 188104 | | 635 | 24098 | | | | | | | | | | | | | |
| | Total | | | | | | | 636 | 193147 | | 636 | 24149 | | | | | | | | | | | | | |
| AGE = 8 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Period | | | | | | | 1 | 569 | 2.18 | 1 | 11 | 0.23 | | | | | | | | | | | | |
| | Residual | | | | | | | 473 | 123328 | | 473 | 21905 | | | | | | | | | | | | | |
| | Total | | | | | | | 474 | 123896 | | 474 | 21916 | | | | | | | | | | | | | |
| AGE = 9 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Main Effect: | Period | | | | | | | 1 | 375 | 1.37 | 1 | 4 | 0.44 | | | | | | | | | | | | |
| | Residual | | | | | | | 252 | 68988 | | 252 | 2452 | | | | | | | | | | | | | |
| | Total | | | | | | | 253 | 69363 | | 253 | 2457 | | | | | | | | | | | | | |

[a] significant at $P = 0.0001$
[b] significant at $P < 0.001$
[c] significant at $P < 0.01$
[d] significant at $P < 0.05$

Table 4.3-18. Von Bertalanffy growth parameters and growth indices (ω) for yellow perch captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1972-1983). Parameters were generated from Ford-Walford plots and the method of Bayley (1977). Data were summarized by year of capture.

| | | | $L_\infty$ | | K | | $t_0$ | | r | | ω | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | AGE GROUP | SEX | BAYLEY | WALFORD | BAYLEY | WALFORD | BAYLEY | WALFORD | BAYLEY | WALFORD | BAYLEY | WALFORD |
| 1972 | 1-4 | Males | 224.7 | 231.9 | 0.6578 | 0.5881 | 0.1680 | 0.1332 | 0.9967 | -0.9994 | 147.8 | 136.4 |
| | | Females | 339.9 | 366.2 | 0.3155 | 0.2778 | -0.0107 | -0.0654 | 0.9985 | -0.9999 | 106.9 | 101.7 |
| | | Combined | 330.4 | 358.2 | 0.3160 | 0.2650 | -0.0167 | -0.1300 | 0.9965 | -0.9998 | 104.4 | 94.9 |
| | 1-8 | Males | 264.3 | 287.3 | 0.4473 | 0.3152 | -0.1495 | -0.3192 | 0.9731 | -0.9977 | 118.2 | 90.6 |
| | | Females | 351.4 | 353.6 | 0.2980 | 0.2920 | -0.0379 | -0.0578 | 0.9984 | -0.9998 | 104.7 | 103.1 |
| | | Combined | 353.1 | 359.5 | 0.2818 | 0.2670 | -0.0625 | 0.1086 | 0.9972 | -0.9997 | 99.5 | 96.0 |
| 1973 | 1-4 | Males | 248.3 | 250.4 | 0.5207 | 0.5116 | 0.1570 | 0.1634 | 0.9999 | -0.9999 | 129.3 | 128.1 |
| | | Females | 341.3 | 363.7 | 0.3191 | 0.2774 | 0.0629 | -0.0262 | 0.9979 | -0.9999 | 108.9 | 100.9 |
| | | Combined | 362.4 | 384.2 | 0.2598 | 0.2310 | -0.0504 | -0.1259 | 0.9987 | -0.9999 | 94.2 | 88.8 |
| | 1-8 | Males | 306.0 | 352.0 | 0.3416 | 0.2242 | -0.0243 | -0.3837 | 0.9790 | -0.9978 | 104.5 | 78.9 |
| | | Females | 345.2 | 348.1 | 0.3131 | 0.3040 | 0.0509 | 0.0037 | 0.9987 | -0.9996 | 108.1 | 105.8 |
| | | Combined | 363.5 | 353.1 | 0.2592 | 0.2870 | -0.0662 | 0.0604 | 0.9969 | -0.9991 | 94.2 | 101.3 |
| 1974 | 1-4 | Males | 398.6 | 480.9 | 0.1917 | 0.1401 | -0.2528 | -0.4330 | 0.9883 | 0.9997 | 76.4 | 67.4 |
| | | Females | 386.1 | 395.6 | 0.2507 | 0.2381 | -0.0420 | -0.0811 | 0.9999 | 0.9999 | 96.8 | 94.2 |
| | | Combined | 488.2 | 559.0 | 0.1678 | 0.1352 | -0.1942 | -0.3080 | 0.9969 | 0.9999 | 81.9 | 75.6 |
| | 1-8 | Males | | | | | | | | | | |
| | | Females | 366.8 | 367.3 | 0.2720 | 0.2700 | -0.0222 | -0.0344 | 0.9986 | -0.9995 | 99.8 | 99.4 |
| | | Combined | 381.6 | 365.8 | 0.2422 | 0.2764 | -0.2252 | 0.0257 | 0.9951 | -0.9997 | 92.4 | 101.1 |
| 1975 | 1-4 | Males | 282.5 | 258.6 | 0.3084 | 0.3848 | 0.1485 | 0.0076 | 0.9847 | -0.9989 | 87.1 | 99.5 |
| | | Females | 401.5 | 373.2 | 0.2018 | 0.2286 | -0.1494 | -0.0975 | 0.9947 | -0.9997 | 81.0 | 85.3 |
| | | Combined | 363.7 | 361.9 | 0.2115 | 0.2125 | -0.2113 | -0.2182 | 0.9995 | 0.9999 | 76.9 | 76.9 |
| | 1-8 | Males | | | | | | | | | | |
| | | Females | 432.5 | 448.9 | 0.1808 | 0.1662 | -0.1600 | -0.2566 | 0.9969 | -0.9998 | 78.2 | 74.6 |
| | | Combined | 410.1 | 388.7 | 0.1783 | 0.2029 | -0.2411 | -0.1252 | 0.9814 | -0.9979 | 73.1 | 78.9 |
| 1976 | 1-4 | Males | 290.4 | 372.6 | 0.4249 | 0.2425 | 0.1966 | -0.1146 | 0.9478 | -0.9961 | 123.4 | 90.4 |
| | | Females | 356.5 | 388.2 | 0.2894 | 0.2436 | 0.0912 | -0.0096 | 0.9974 | -0.9999 | 103.2 | 94.6 |
| | | Combined | 376.5 | 385.6 | 0.2311 | 0.2213 | -0.0227 | -0.0622 | 0.9999 | 0.9999 | 87.8 | 85.3 |
| | 1-8 | Males | 354.2 | 400.8 | 0.2954 | 0.2107 | 0.0382 | -0.2133 | 0.9611 | 0.9973 | 104.6 | 84.5 |
| | | Females | 357.4 | 364.3 | 0.2878 | 0.2727 | 0.0679 | 0.0295 | 0.9983 | -0.9997 | 102.9 | 99.3 |
| | | Combined | 378.7 | 374.9 | 0.2314 | 0.2401 | 0.0496 | 0.0201 | 0.9986 | -0.9993 | 87.6 | 90.1 |
| 1977 | 1-4 | Males | 257.2 | 280.2 | 0.3881 | 0.3126 | -0.0125 | -0.1844 | 0.9926 | -0.9995 | 99.8 | 87.6 |
| | | Females | 319.6 | 335.0 | 0.3243 | 0.2918 | 0.0788 | 0.0114 | 0.9992 | -0.9999 | 103.7 | 97.7 |
| | | Combined | 305.7 | 331.8 | 0.3112 | 0.2605 | -0.0048 | -0.1201 | 0.9964 | 0.9998 | 95.1 | 86.4 |
| | 1-8 | Males | 392.2 | 436.4 | 0.1889 | 0.1545 | -0.3625 | -0.4088 | 0.9541 | -0.9953 | 74.1 | 67.4 |
| | | Females | 345.6 | 351.7 | 0.2846 | 0.2724 | -0.0026 | 0.0053 | 0.9972 | -0.9988 | 98.4 | 95.8 |
| | | Combined | 362.2 | 374.8 | 0.2353 | 0.2183 | -0.1281 | -0.1374 | 0.9938 | -0.9992 | 85.2 | 81.8 |
| 1978 | 1-4 | Males | 265.5 | 250.1 | 0.4197 | 0.5058 | 0.1074 | 0.2405 | 0.9952 | -0.9994 | 111.4 | 126.5 |
| | | Females | 360.9 | 358.0 | 0.2810 | 0.2843 | 0.0438 | 0.0406 | 0.9991 | -0.9999 | 101.4 | 101.8 |
| | | Combined | 291.9 | 298.7 | 0.3803 | 0.3591 | 0.1116 | 0.0760 | 0.9999 | -0.9999 | 111.0 | 107.3 |
| | 1-8 | Males | | | | | | | | | | |
| | | Females | 387.3 | 406.0 | 0.2508 | 0.2157 | 0.0460 | -0.1723 | 0.9957 | -0.9985 | 97.1 | 87.6 |
| | | Combined | 364.1 | 384.1 | 0.2597 | 0.2297 | -0.0620 | -0.0562 | 0.9850 | -0.9968 | 94.6 | 88.2 |
| 1980 | 1-4 | Males | 239.4 | 235.1 | 0.4620 | 0.4931 | 0.1540 | 0.2109 | 0.9993 | -0.9999 | 110.6 | 115.9 |
| | | Females | 466.4 | 582.7 | 0.1762 | 0.1253 | 0.0319 | -0.1163 | 0.9931 | -0.9997 | 82.2 | 73.0 |
| | | Combined | 350.4 | 388.7 | 0.2574 | 0.2116 | 0.0759 | -0.0344 | 0.9973 | -0.9999 | 90.2 | 82.2 |
| | 1-8 | Males | 316.9 | 379.3 | 0.2786 | 0.1759 | -0.1844 | -0.4810 | 0.9619 | -0.9854 | 88.3 | 66.7 |
| | | Females | 377.7 | 345.1 | 0.2394 | 0.3254 | 0.0465 | 0.3926 | 0.9930 | -0.9986 | 90.4 | 112.3 |
| | | Combined | 375.8 | 353.6 | 0.2330 | 0.2887 | -0.0084 | 0.2973 | 0.9917 | -0.9976 | 87.6 | 102.1 |
| 1981 | 1-4 | Males | 215.9 | 206.4 | 0.4692 | 0.5486 | 0.1466 | 0.2623 | 0.9937 | -0.9990 | 101.3 | 113.2 |
| | | Females | 317.9 | 311.0 | 0.2681 | 0.2764 | 0.0913 | 0.0827 | 0.9970 | -0.9997 | 85.2 | 86.0 |
| | | Combined | 280.1 | 273.8 | 0.3225 | 0.3703 | 0.0901 | 0.0644 | 0.9940 | -0.9994 | 90.4 | 101.4 |
| | 1-8 | Males | 309.4 | 397.0 | 0.2447 | 0.1404 | -0.1611 | -0.5363 | 0.9460 | -0.9904 | 75.7 | 55.7 |
| | | Females | 432.6 | 393.9 | 0.1727 | 0.2030 | -0.0712 | 0.2992 | 0.9720 | -0.9949 | 74.7 | 80.0 |
| | | Combined | 408.8 | 415.3 | 0.1790 | 0.1826 | -0.1810 | 0.0400 | 0.9685 | -0.9967 | 73.2 | 75.8 |
| 1982 | 1-4 | Males | 233.8 | 214.7 | 0.4084 | 0.5329 | 0.0734 | 0.2582 | 0.9835 | -0.9980 | 95.5 | 114.4 |
| | | Females | 927.9 | 1132.4 | 0.0700 | 0.0547 | -0.1631 | -0.2352 | 0.9999 | -0.9999 | 65.0 | 61.9 |
| | | Combined | 338.4 | 323.3 | 0.2425 | 0.2630 | 0.0050 | 0.0350 | 0.9897 | -0.9992 | 82.1 | 85.0 |
| | 1-8 | Males | 516.4 | 710.7 | 0.1175 | 0.0724 | -0.2224 | -0.4853 | 0.8343 | -0.9892 | 60.7 | 51.4 |
| | | Females | 427.3 | 355.2 | 0.1861 | 0.3199 | -0.0952 | 0.4846 | 0.9851 | -0.9960 | 79.5 | 113.6 |
| | | Combined | 427.2 | 416.4 | 0.1749 | 0.1938 | -0.1749 | 0.0797 | 0.9722 | -0.9932 | 74.7 | 80.7 |
| 1983 | 1-4 | Males | 223.5 | 210.3 | 0.4360 | 0.5316 | 0.1109 | 0.2531 | 0.9914 | -0.9989 | 97.4 | 111.8 |
| | | Females | 427.0 | 731.0 | 0.1908 | 0.0915 | 0.0099 | -0.2613 | 0.9999 | -0.9992 | 81.5 | 66.9 |
| | | Combined | 307.2 | 299.1 | 0.2909 | 0.3069 | 0.0659 | 0.0887 | 0.9975 | -0.9998 | 89.4 | 91.8 |
| | 1-8 | Males | 528.6 | 688.0 | 0.1118 | 0.0778 | -0.2506 | -0.2817 | 0.8453 | -0.9823 | 59.1 | 53.5 |
| | | Females | 417.2 | 366.2 | 0.1991 | 0.2945 | -0.0426 | 0.4104 | 0.9876 | -0.9968 | 83.1 | 107.8 |
| | | Combined | 444.7 | 389.5 | 0.1698 | 0.2454 | -0.1344 | 0.3534 | 0.9547 | -0.9937 | 75.5 | 95.6 |

Table 4.3-19. Von Bertalanffy growth parameters and growth indicies ($\omega$) for yellow perch captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1971-1983). Parameters were generated from Ford-Walford plots and the method of Bayley (1977). Data were summarized by year class.

| | | | $L_\infty$ | | K | | $t_0$ | | r | | $\omega$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR CLASS | AGE GROUP | SEX | Bayley | Walford | Bayley | Walford | Bayley | Walford | Bayley | Walford | Bayley | Walford |
| 1968 | 1-4 | Males | | | | | | | | | | |
| | 1-4 | Females | 304.2 | 312.0 | 0.3978 | 0.3728 | 0.0749 | 0.0351 | 0.9997 | -0.9999 | 121.0 | 116.3 |
| | 1-4 | Combined | 328.2 | 352.8 | 0.3209 | 0.2733 | 0.0191 | -0.0856 | 0.9958 | -0.9998 | 105.3 | 96.4 |
| 1969 | 1-4 | Males | 254.5 | 256.9 | 0.4984 | 0.4874 | 0.1593 | 0.1579 | 0.9999 | -0.9999 | 126.8 | 125.2 |
| | 1-4 | Females | 307.1 | 310.3 | 0.4076 | 0.3979 | 0.1480 | 0.1359 | 0.9999 | -0.9999 | 125.3 | 123.5 |
| | 1-4 | Combined | 334.4 | 346.0 | 0.3129 | 0.2891 | 0.0714 | 0.0123 | 0.9999 | -0.9999 | 104.6 | 100.0 |
| 1970 | 1-4 | Males | 274.9 | 313.4 | 0.4299 | 0.3071 | 0.0624 | -0.1654 | 0.9745 | -0.9979 | 118.2 | 96.2 |
| | 1-4 | Females | 316.8 | 329.1 | 0.3626 | 0.3306 | 0.0867 | 0.0272 | 0.9999 | -0.9999 | 114.9 | 108.8 |
| | 1-4 | Combined | 345.1 | 392.8 | 0.2918 | 0.2245 | -0.0226 | -0.1862 | 0.9860 | -0.9991 | 100.7 | 88.2 |
| 1971 | 1-4 | Males | 309.1 | 283.1 | 0.2586 | 0.3126 | -0.2035 | -0.0823 | 0.9870 | -0.9992 | 79.9 | 88.5 |
| | 1-4 | Females | 483.4 | 419.7 | 0.1558 | 0.1908 | -0.1772 | -0.0963 | 0.9880 | -0.9995 | 75.3 | 80.1 |
| | 1-4 | Combined | 358.7 | 341.7 | 0.2311 | 0.2531 | -0.1531 | -0.1064 | 0.9960 | -0.9998 | 82.9 | 86.5 |
| 1972 | 1-4 | Males | 224.2 | 206.2 | 0.5217 | 0.7861 | 0.0090 | 0.3581 | 0.9791 | -0.9965 | 117.0 | 162.1 |
| | 1-4 | Females | 420.6 | 428.1 | 0.1973 | 0.1901 | -0.0807 | -0.1137 | 0.9994 | -0.9999 | 83.0 | 81.4 |
| | 1-4 | Combined | 355.9 | 415.2 | 0.2297 | 0.1739 | -0.1578 | -0.3245 | 0.9897 | -0.9996 | 81.8 | 72.2 |
| 1973 | 1-4 | Males | 254.6 | 262.3 | 0.4350 | 0.4012 | 0.0858 | 0.0368 | 0.9999 | -0.9999 | 110.8 | 105.2 |
| | 1-4 | Females | 439.1 | 436.1 | 0.1930 | 0.1923 | 0.0068 | -0.0249 | 0.9992 | -0.9999 | 84.7 | 83.9 |
| | 1-4 | Combined | 418.1 | 422.0 | 0.1913 | 0.1868 | -0.0820 | -0.1098 | 0.9999 | -0.9999 | 80.0 | 78.8 |
| 1974 | 1-4 | Males | 327.8 | 365.6 | 0.2577 | 0.2084 | -0.0927 | -0.2260 | 0.9942 | -0.9997 | 84.5 | 76.2 |
| | 1-4 | Females | 532.0 | 537.0 | 0.1501 | 0.1463 | -0.0679 | -0.0951 | 0.9997 | -0.9999 | 79.9 | 78.6 |
| | 1-4 | Combined | 429.2 | 470.0 | 0.1931 | 0.1652 | -0.0652 | -0.1527 | 0.9986 | -0.9999 | 82.9 | 77.6 |
| 1975 | 1-4 | Males | 293.1 | 289.8 | 0.3419 | 0.3480 | 0.0300 | 0.0459 | 0.9989 | -0.9999 | 100.2 | 100.8 |
| | 1-4 | Females | 462.1 | 424.9 | 0.2013 | 0.2104 | 0.0524 | 0.0933 | 0.9943 | -0.9996 | 93.0 | 97.9 |
| | 1-4 | Combined | 417.6 | 435.4 | 0.2181 | 0.2014 | 0.0091 | -0.0435 | 0.9999 | -0.9999 | 91.1 | 87.7 |
| 1976 | 1-4 | Males | 285.3 | 255.7 | 0.2785 | 0.3534 | -0.0076 | 0.1254 | 0.9865 | -0.9990 | 79.5 | 90.4 |
| | 1-4 | Females | 385.8 | 349.6 | 0.2324 | 0.2770 | 0.0855 | 0.1525 | 0.9929 | -0.9995 | 89.7 | 96.8 |
| | 1-4 | Combined | 245.1 | 209.7 | 0.4360 | 0.7848 | 0.1536 | 0.5375 | 0.9636 | -0.9941 | 106.9 | 164.6 |
| 1977 | 1-4 | Males | 205.3 | 191.7 | 0.5645 | 0.7814 | 0.1951 | 0.4404 | 0.9870 | -0.9971 | 115.9 | 149.8 |
| | 1-4 | Females | 330.4 | 325.3 | 0.2772 | 0.2829 | 0.1135 | 0.1132 | 0.9982 | -0.9998 | 91.6 | 92.2 |
| | 1-4 | Combined | 265.6 | 254.1 | 0.3761 | 0.4007 | 0.1401 | 0.2158 | 0.9973 | -0.9997 | 98.3 | 101.9 |
| 1978 | 1-4 | Males | 235.7 | 221.5 | 0.3884 | 0.4477 | 0.0438 | 0.1753 | 0.9908 | -0.9990 | 91.5 | 99.2 |
| | 1-4 | Females | 642.3 | 945.0 | 0.1031 | 0.0627 | -0.1649 | -0.3191 | 0.9922 | -0.9998 | 66.2 | 59.2 |
| | 1-4 | Combined | 298.3 | 275.2 | 0.2850 | 0.3389 | 0.0058 | 0.1004 | 0.9923 | -0.9994 | 85.0 | 93.3 |
| 1979 | 1-4 | Males | 213.1 | 196.8 | 0.5091 | 0.7030 | 0.1722 | 0.4031 | 0.9828 | -0.9967 | 108.5 | 138.4 |
| | 1-4 | Females | 356.0 | 312.1 | 0.2320 | 0.2959 | 0.0551 | -0.1581 | -0.9877 | -0.9992 | 82.6 | 92.3 |
| | 1-4 | Combined | 260.8 | 224.1 | 0.3704 | 0.5768 | 0.1257 | 0.1948 | 0.9685 | -0.9962 | 96.6 | 129.3 |

Table 4.3-20. Von Bertalanffy growth parameters and growth indices ($\omega$) for rock bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1974-1983). Parameters were generated from Ford-Walford plots and the method of Bayley (1977). Data were summarized by year of capture.

| YEAR | AGE GROUP | SEX | $L_\infty$ |  | K |  | $t_o$ |  | r |  | $\omega$ |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Bayley | Walford | Bayley | Walford | Bayley | Walford | Bayley | Walford | Bayley | Walford |
| 1974 | 1-8 | Combined | 483.6 |  | 0.0981 |  | -0.2042 |  | 0.9599 |  | 47.4 |  |
| 1975 | 1-10 | Combined | 354.8 | 280.4 | 0.1445 | 0.2865 | -0.2721 | 0.5393 | 0.9701 | -0.9982 | 51.3 | 80.3 |
| 1976 | 1-10 | Combined | 373.9 | 299.6 | 0.1331 | 0.2248 | -0.1907 | 0.2684 | 0.9712 | -0.9990 | 49.8 | 67.3 |
| 1977 | 1-10 | Combined | 372.6 | 302.3 | 0.1311 | 0.2197 | -0.2754 | 0.2955 | 0.9802 | -0.9985 | 48.8 | 66.4 |
| 1978 | 1-10 | Combined | 358.9 | 299.5 | 0.1350 | 0.2136 | -0.3464 | 0.2018 | 0.9703 | -0.9912 | 48.5 | 64.0 |
| 1980 | 1-10 | Males | 333.1 | 277.9 | 0.1685 | 0.2884 | -0.1763 | 0.3156 | 0.9626 | -0.9779 | 56.1 | 80.1 |
|  | 1-10 | Females | 342.5 | 283.5 | 0.1511 | 0.2355 | -0.0144 | 0.2340 | 0.9756 | -0.9978 | 51.6 | 66.8 |
|  | 1-10 | Combined | 332.6 | 263.4 | 0.1642 | 0.3682 | -0.1306 | 0.8156 | 0.9698 | -0.9947 | 43.4 | 97.0 |
| 1981 | 1-10 | Males | 387.0 | 272.4 | 0.1228 | 0.3320 | -0.3440 | 0.7778 | 0.9506 | -0.9972 | 47.5 | 90.4 |
|  | 1-10 | Females | 374.2 | 277.3 | 0.1224 | 0.2666 | -0.3644 | 0.5140 | 0.9618 | -0.9982 | 45.8 | 73.9 |
|  | 1-10 | Combined | 369.6 | 273.3 | 0.1318 | 0.3072 | -0.2785 | 0.6504 | 0.9584 | -0.9983 | 48.7 | 83.9 |
| 1982 | 1-10 | Males | 427.3 | 294.6 | 0.1137 | 0.2942 | -0.2959 | 0.7035 | 0.9516 | -0.9981 | 48.6 | 86.7 |
|  | 1-10 | Females | 382.4 | 277.8 | 0.1233 | 0.2906 | -0.3322 | 0.6258 | 0.9555 | -0.9978 | 47.1 | 80.7 |
|  | 1-10 | Combined | 402.5 | 287.8 | 0.1200 | -0.2884 | -0.3004 | 0.6412 | 0.9561 | 0.9982 | 48.3 | 83.0 |
| 1983 | 1-10 | Males | 425.3 | 294.6 | 0.1091 | 0.2677 | -0.3620 | 0.5836 | 0.9524 | -0.9977 | 46.4 | 78.9 |
|  | 1-10 | Females | 380.1 | 278.1 | 0.1199 | 0.2614 | -0.3290 | 0.4764 | 0.9560 | -0.9987 | 45.6 | 72.7 |
|  | 1-10 | Combined | 401.9 | 284.7 | 0.1147 | 0.2699 | -0.3397 | 0.5454 | 0.9517 | -0.9985 | 46.1 | 76.8 |

Table 4.3-21. Von Bertalanffy growth parameters and growth indices ($\omega$) for rock bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1974-1983). Parameters were generated from Ford-Walford plots and the method of Bayley (1977). Data were summarized by year class.

| | | | $L_\infty$ | | K | | $t_o$ | | r | | $\omega$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **YEAR CLASS** | **SEX** | **AGE GROUP** | **BAYLEY** | **WALFORD** | **BAYLEY** | **WALFORD** | **BAYLEY** | **WALFORD** | **BAYLEY** | **WALFORD** | **BAYLEY** | **WALFORD** |
| 1972 | Combined | 1-4 | 1073.1 | 1066.9 | -0.0313 | 0.0372 | -0.8565 | -0.2692 | 0.9875 | -0.9996 | 33.6 | 39.7 |
| 1973 | Combined | 1-4 | 523.9 | 1116.2 | -0.0616 | 0.0372 | -1.3811 | -0.2066 | 0.9626 | -0.9992 | 32.3 | 41.5 |
| 1974 | Combined | 1-4 | 579.1 | 1358.5 | -0.0586 | 0.0322 | -1.2129 | -0.1750 | 0.9851 | -0.9994 | 33.9 | 43.7 |
| 1975 | Combined | 1-4 | 703.8 | 721.7 | -0.0508 | 0.0650 | -1.0179 | -0.0632 | 0.9815 | -0.9957 | 35.8 | 46.9 |
| 1976 | Combined | 1-4 | 1344.3 | 645.1 | -0.0281 | 0.0766 | -0.6655 | -0.0771 | 0.9845 | -0.9991 | 37.8 | 49.4 |
| 1977 | Combined | 1-4 | 293.5 | | -0.0958 | | -2.6356 | | 0.9660 | | 28.1 | |
| 1978 | Combined | 1-4 | 235.9 | 802.2 | -0.1165 | 0.0584 | -0.3669 | -0.1089 | 0.9718 | -0.9979 | 27.5 | 46.8 |
| 1979 | Combined | 1-4 | 1056.0 | 2818.8 | -0.0347 | 0.0148 | -0.7992 | -0.2748 | 0.9529 | -0.9996 | 36.6 | 41.7 |

Table 4.3-22. Age-specific correlations of backcalculated fork lengths (mm) and last increments of growth (mm) with year for yellow perch (1971-1983), rock bass (1974-1983), smallmouth bass (1972-1983) and white bass (1971-1983) captured at standard Nanticoke locations, Long Point Bay, Lake Erie.

| VARIABLE | N | COEFFICIENT* | AGE I | II | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|---|---|---|
| **YELLOW PERCH** | | | | | | | | | | |
| Fork Length at Last Annulus | 12<br>12 | $r_s$<br>$\tau$ | | -0.539$^d$<br>-0.394$^d$ | -0.636$^c$<br>-0.485$^c$ | -0.762$^a$<br>-0.576$^b$ | -0.643$^b$<br>-0.485$^c$ | 0.126<br>0.061 | 0.559$^c$<br>0.455$^c$ | |
| Last Increment of Growth | 12<br>12 | $r_s$<br>$\tau$ | | -0.105<br>-0.091 | 0.546$^d$<br>0.424$^c$ | -0.028<br>0.000 | -0.056<br>-0.061 | 0.504$^d$<br>0.333 | 0.253<br>0.215 | |
| **ROCK BASS** | | | | | | | | | | |
| Fork Length at Last Annulus | 9<br>9 | $r_s$<br>$\tau$ | | | -0.483<br>-0.333 | 0.117<br>0.167 | 0.633$^d$<br>0.389 | 0.283<br>0.111 | 0.633$^d$<br>0.389 | 0.117<br>0.111 |
| Last Increment of Growth | 9<br>9 | $r_s$<br>$\tau$ | | | 0.100<br>0.056 | 0.217<br>0.222 | 0.850$^a$<br>0.667$^b$ | 0.433<br>0.278 | 0.583$^d$<br>0.333 | 0.300<br>0.222 |
| **SMALLMOUTH BASS** | | | | | | | | | | |
| Fork Length at Last Annulus | 11<br>11 | $r_s$<br>$\tau$ | | | 0.391<br>0.309 | 0.427<br>0.273 | 0.264<br>0.200 | 0.524$^d$<br>0.440$^d$ | | |
| Last Increment of Growth | 11<br>11 | $r_s$<br>$\tau$ | | | 0.427<br>0.309 | 0.445<br>0.273 | 0.718$^c$<br>0.564$^c$ | 0.464<br>0.346 | | |
| **WHITE BASS** | | | | | | | | | | |
| Fork Length at Last Annulus | 12<br>12 | $r_s$<br>$\tau$ | 0.203<br>0.152 | 0.084<br>0.061 | | | | | | |
| Last Increment of Growth | 12<br>12 | $r_s$<br>$\tau$ | | 0.014<br>-0.061 | | | | | | |

* $r_s$ = Spearman's Rank Correlation Coefficient

$\tau$ = Kendall's Tau B Correlation Coefficient

a = significant at $P < 0.005$

b = significant at $P < 0.01$

c = significant at $P < 0.05$

d = significant at $P < 0.10$

Table 4.3-23. Spearman's Rank ($r_s$) and Kendall's tau (t) correlation coefficent between age-specific last increments of growth and fork lengths at last annulus for yellow perch.

| AGE GROUP | SPEARMAN'S RANK $r_s$ | SPEARMAN'S RANK P | KENDALL'S tau $r_t$ | KENDALL'S tau P |
|---|---|---|---|---|
| II | 0.6126 | 0.0001 | 0.4568 | 0.0001 |
| III | 0.2820 | 0.0001 | 0.1974 | 0.0001 |
| IV | 0.5159 | 0.0001 | 0.3640 | 0.0001 |
| V | 0.5619 | 0.0001 | 0.3966 | 0.0001 |
| VI | 0.1183 | 0.0613 | 0.0811 | 0.0638 |
| VII | 0.2263 | 0.0021 | 0.1584 | 0.0023 |

Table 4.3-24. Weighted mean backcalculated fork lengths (mm), recruitment indices (year class strengths) and correlation coefficients of fork length vs year class strength for rock bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1971-1980). Sexes combined.

| YEAR CLASS | N | AGE (Years) | | | | | | | | | | | Recruitment[2] Indices I IV-VI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | |
| 1971 | 261 | 53.3 | 87.4 | 129.0 | 164.6 | 193.0 | 215.1 | 233.7 | 244.7 | 254.3 | 263.2 | 275.4 | 32.3 |
| 1972 | 336 | 51.9 | 86.4 | 125.3 | 161.0 | 192.2 | 217.0 | 235.0 | 247.5 | 253.9 | 266.7 | 270.8 | 17.3 |
| 1973 | 455 | 52.3 | 87.2 | 129.9 | 167.1 | 199.4 | 222.8 | 238.3 | 248.6 | 260.9 | 261.9 | | 15.6 |
| 1974 | 438 | 52.3 | 88.9 | 131.6 | 171.5 | 205.2 | 227.6 | 241.6 | 253.3 | 254.9 | | | 6.8 |
| 1975 | 605 | 52.8 | 90.6 | 134.9 | 175.2 | 205.9 | 225.7 | 242.6 | 248.2 | | | | 2.5 |
| 1976 | 680 | 53.4 | 91.6 | 135.2 | 174.1 | 204.3 | 226.3 | 240.0 | | | | | 3.3 |
| 1977 | 3373 | 53.4 | 86.8 | 128.2 | 167.1 | 202.1 | 219.4 | | | | | | 30.0 |
| 1978 | 1232 | 54.1 | 88.5 | 131.4 | 173.5 | 202.1 | | | | | | | |
| 1979 | 255 | 53.4 | 90.5 | 136.1 | 172.6 | | | | | | | | |
| 1980 | 62 | 53.7 | 94.8 | 136.9 | | | | | | | | | |
| r[1]$_{(72-76)}$ | | -.810[a] | -.960[a] | -.985[a] | -.958[a] | -.904[a] | -.837[a] | -.887[a] | | | | | |
| r[1]$_{(71-77)}$ | | .277 | -.787[b] | -.731[c] | -.744[c] | -.663 | -.873[b] | -.914[3, a] | | | | | |

[1] Correlation coefficient of Fork Lengths at Age regressed on recruitment indices

[2] Derived from CUE's of spring trapnet catches at Oneida

[3] Includes only year classes 1971-1976

[a] Significant at P<0.01

[b] Significant at P<0.05

[c] Significant at P=0.06

Table 4.3-25. Relative indices of year class strengths and weighted mean backcalculated fork lengths (mm) at age for yellow perch year classes (1968-1981) captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1971-1983).

| YEAR CLASS | N | AGE (YEARS) | | | | | | | | | | | Indices of Year Class Strength | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | Trap Net I3-6 | Age I* | I2-8* |
| FEMALES | | | | | | | | | | | | | | | |
| 1968 | 26 | 94.0 | 162.5 | 208.4 | 240.9 | 271.7 | 287.1 | 307.3 | 315.0 | 324.0 | | | | 25 | 37 |
| 1969 | 24 | 90.4 | 162.1 | 211.4 | 243.5 | 261.5 | 282.5 | 293.0 | 300.0 | | | | | 70 | 94 |
| 1970 | 76 | 90.0 | 158.2 | 206.0 | 240.5 | 263.4 | 288.1 | 300.6 | 314.8 | 318.8 | 326.5 | | | 103 | 150 |
| 1971 | 67 | 81.5 | 137.5 | 191.6 | 229.6 | 261.9 | 284.8 | 301.4 | 311.4 | 321.4 | 334.0 | 336.5 | 18.50 | 159 | 232 |
| 1972 | 45 | 81.8 | 141.1 | 192.0 | 232.0 | 261.4 | 288.3 | 306.0 | 317.6 | 320.7 | 325.4 | 340.0 | 7.14 | 33 | 51 |
| 1973 | 62 | 78.8 | 140.4 | 193.9 | 235.7 | 270.5 | 293.7 | 309.4 | 321.2 | 331.2 | 331.0 | | 8.45 | 62 | 86 |
| 1974 | 67 | 80.2 | 141.6 | 196.4 | 242.4 | 274.1 | 295.8 | 314.7 | 324.0 | 334.3 | | | 7.03 | 31 | 47 |
| 1975 | 94 | 81.3 | 148.4 | 209.3 | 251.7 | 281.3 | 304.3 | 321.8 | 326.7 | | | | 5.88 | 75 | 93 |
| 1976 | 112 | 74.7 | 137.0 | 192.6 | 228.8 | 264.0 | 297.5 | 313.3 | | | | | 3.11 | 28 | 39 |
| 1977 | 600 | 72.9 | 133.6 | 183.2 | 217.1 | 278.4 | 301.2 | | | | | | 9.29 | 75 | 115 |
| 1978 | 675 | 74.4 | 129.5 | 176.1 | 224.6 | 267.7 | | | | | | | 8.30 | 50 | 69 |
| 1979 | 997 | 70.6 | 127.5 | 179.7 | 211.5 | | | | | | | | | 48 | 70 |
| 1980 | 272 | 78.1 | 137.2 | 182.0 | | | | | | | | | | 22 | 28 |
| 1981 | 211 | 75.7 | 137.3 | | | | | | | | | | | 66 | 83 |
| SEXES COMBINED | | | | | | | | | | | | | | | |
| 1968 | 68 | 89.9 | 155.0 | 199.6 | 237.7 | 272.0 | 291.3 | 306.6 | 318.9 | 324.0 | | | | 25 | 37 |
| 1969 | 238 | 85.3 | 151.2 | 200.2 | 236.7 | 268.4 | 288.0 | 302.6 | 313.3 | 339.0 | | | | 70 | 94 |
| 1970 | 296 | 90.7 | 155.3 | 198.0 | 240.0 | 263.9 | 285.4 | 299.3 | 313.2 | 318.8 | 326.5 | | | 103 | 150 |
| 1971 | 315 | 84.3 | 139.6 | 187.2 | 220.5 | 254.5 | 283.8 | 305.4 | 311.4 | 321.4 | 334.0 | 336.5 | 18.50 | 159 | 232 |
| 1972 | 187 | 84.5 | 140.2 | 180.6 | 219.9 | 255.4 | 283.2 | 301.8 | 313.7 | 316.8 | 324.9 | 340.0 | 7.14 | 33 | 51 |
| 1973 | 216 | 79.4 | 137.2 | 185.9 | 226.3 | 262.8 | 292.7 | 308.2 | 319.1 | 330.6 | 331.0 | | 8.45 | 62 | 86 |
| 1974 | 188 | 81.3 | 141.5 | 190.2 | 233.6 | 271.4 | 292.6 | 309.8 | 325.4 | 336.8 | | | 7.03 | 31 | 47 |
| 1975 | 241 | 82.6 | 146.9 | 199.6 | 242.5 | 270.5 | 293.0 | 318.7 | 327.5 | | | | 5.88 | 75 | 93 |
| 1976 | 255 | 73.8 | 132.2 | 182.0 | 195.7 | 273.6 | 297.1 | 315.3 | | | | | 3.11 | 28 | 39 |
| 1977 | 1673 | 72.6 | 131.0 | 175.2 | 201.2 | 253.1 | 297.9 | | | | | | 9.29 | 75 | 115 |
| 1978 | 1696 | 73.8 | 127.9 | 173.8 | 201.5 | 252.0 | | | | | | | 8.30 | 50 | 69 |
| 1979 | 2204 | 71.1 | 127.6 | 177.5 | 195.6 | | | | | | | | | 48 | 70 |
| 1980 | 597 | 77.1 | 136.1 | 179.3 | | | | | | | | | | 22 | 28 |
| 1981 | 314 | 76.3 | 138.3 | | | | | | | | | | | 66 | 83 |

* Derived from cohort analyses.

Table 4.3-26. Total annual smallmesh gillnet effort (km) expended in Statistical District 4, Lake Erie, weighted mean backcalculated fork lengths (mm) of yellow perch and age-specific correlation coefficients between fork lengths and effort. Nanticoke, Long Point Bay, Lake Erie (1972-1983).

| | | AGE (Males) | | | | | AGE (Females) | | | | | AGE (Sexes Combined) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | EFFORT (km) | I | II | III | IV | V | I | II | III | IV | V | I | II | III | IV | V |
| WEIGHTED MEAN BACKCALCULATED FORK LENGTH | | | | | | | | | | | | | | | | |
| 1972 | 5196 | 91.4 | 156.7 | 187.6 | 208.3 | 236.3 | 94.1 | 159.4 | 210.2 | 243.8 | 274.1 | 91.8 | 156.2 | 200.8 | 238.5 | 269.4 |
| 1973 | 5348 | 87.1 | 152.3 | 192.1 | 215.1 | 244.0 | 89.5 | 157.7 | 205.6 | 244.9 | 273.5 | 87.7 | 149.9 | 196.9 | 236.3 | 271.0 |
| 1974 | 4000 | 86.5 | 141.0 | 182.0 | 223.0 | | 89.8 | 154.4 | 205.8 | 245.8 | 273.4 | 90.1 | 151.0 | 200.6 | 247.0 | 273.5 |
| 1975 | 4892 | 83.8 | 135.1 | 178.9 | 202.5 | 244.0 | 83.7 | 140.2 | 190.7 | 226.6 | 259.7 | 82.8 | 135.4 | 179.7 | 214.1 | 258.7 |
| 1976 | 4928 | 85.8 | 158.2 | 192.2 | 237.0 | 261.2 | 84.0 | 151.7 | 200.6 | 242.3 | 268.4 | 81.0 | 141.3 | 190.1 | 228.9 | 259.9 |
| 1977 | 5043 | 85.4 | 141.0 | 175.3 | 204.7 | 249.5 | 83.6 | 148.2 | 194.4 | 230.5 | 260.4 | 83.2 | 142.4 | 183.6 | 218.6 | 251.7 |
| 1978 | 5154 | 82.4 | 144.0 | 189.3 | 212.7 | 219.3 | 85.9 | 151.8 | 204.5 | 241.6 | 273.6 | 84.2 | 149.2 | 194.1 | 225.7 | 256.8 |
| 1980 | 6337 | 76.9 | 136.4 | 176.1 | 198.8 | 239.2 | 75.3 | 137.7 | 186.7 | 235.3 | 271.3 | 75.8 | 137.3 | 183.2 | 223.4 | 266.3 |
| 1981 | 8961 | 70.3 | 123.9 | 162.1 | 179.5 | 205.7 | 70.6 | 126.0 | 173.4 | 205.4 | 259.5 | 71.5 | 127.5 | 173.1 | 199.7 | 247.0 |
| 1982 | 9052 | 72.7 | 125.3 | 167.3 | 185.0 | 208.8 | 73.9 | 130.4 | 183.6 | 234.1 | 272.6 | 72.9 | 128.2 | 177.7 | 208.4 | 256.1 |
| 1983 | 8189 | 71.0 | 123.8 | 162.3 | 181.3 | 206.8 | 74.9 | 134.6 | 185.5 | 227.1 | 276.2 | 73.7 | 131.2 | 177.8 | 208.4 | 269.4 |
| $r_{(FL \cdot Effort)}$ | | -.905[a] | -.767[a] | -.816[a] | -.857[a] | -.845[a] | -.851[a] | -.854[a] | -.824[a] | -.667[b] | -.013 | -.865[a] | -.805[a] | -.757[a] | -.805[a] | -.383 |

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[a] significant at $P < 0.01$

[b] significant at $P < 0.05$

Table 4.3-27. Weighted mean backcalculated fork lengths (mm) and indices of spawning stock size for yellow perch captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1971-1983).

| YEAR OF CAPTURE | N | AGE I | II | III | IV | V | VI | VII | VIII | IX | X | XI | SPAWNING STOCK Σ 3+ | Σ 2-8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | MALES | | | | | | | | |
| 1972 | 82 | 91.4 | 156.7 | 187.6 | 208.3 | 236.3 | 247.0 | 259.0 | | | | | 32 | 114 |
| 1973 | 59 | 87.1 | 152.3 | 192.1 | 215.1 | 244.0 | 271.0 | 284.0 | | | | | 60 | 187 |
| 1974 | 16 | 86.5 | 141.0 | 182.0 | 223.0 | | | | | | | | 96 | 122 |
| 1975 | 43 | 83.8 | 135.3 | 178.9 | 202.5 | 244.0 | | | | | | | 45 | 94 |
| 1976 | 12 | 85.8 | 158.2 | 192.2 | 217.0 | 261.2 | 295.7 | 318.0 | 326.5 | 329.0 | | | 37 | 61 |
| 1977 | 42 | 85.4 | 141.0 | 175.3 | 204.7 | 249.5 | 278.4 | 305.0 | 311.0 | | | | 25 | 85 |
| 1978 | 24 | 82.4 | 144.0 | 189.3 | 212.7 | 219.3 | | | | | | | 33 | 56 |
| 1979 | | | | | | No | Data | | | | | | 17 | 77 |
| 1980 | 438 | 76.9 | 136.4 | 176.1 | 198.8 | 239.2 | 263.7 | 288.7 | 281.5 | | | | 42 | 82 |
| 1981 | 659 | 70.3 | 123.9 | 162.1 | 179.5 | 205.7 | 247.5 | 267.3 | 269.4 | 272.0 | | | 40 | 77 |
| 1982 | 494 | 72.7 | 125.3 | 167.3 | 185.0 | 208.8 | 282.3 | 296.0 | 329.0 | | | | 33 | 49 |
| 1983 | 314 | 71.0 | 123.8 | 163.2 | 181.3 | 206.8 | 252.3 | 321.0 | 328.0 | | | | 17 | 70 |
| | | | | | | FEMALES | | | | | | | | |
| 1972 | 91 | 94.1 | 159.4 | 210.2 | 241.8 | 274.1 | 291.3 | 308.6 | 320.2 | | | | 32 | 114 |
| 1973 | 40 | 89.5 | 157.7 | 205.6 | 244.9 | 273.5 | 291.6 | 304.4 | 317.5 | 209.0 | | | 60 | 187 |
| 1974 | 44 | 89.8 | 154.4 | 205.8 | 245.8 | 273.4 | 292.4 | 314.0 | 325.3 | | | | 96 | 122 |
| 1975 | 42 | 83.7 | 140.2 | 190.7 | 226.6 | 259.7 | 290.5 | 315.0 | | | | | 45 | 94 |
| 1976 | 14 | 84.0 | 151.7 | 200.6 | 242.3 | 268.4 | 291.0 | 311.0 | 322.0 | 333.0 | | | 37 | 61 |
| 1977 | 45 | 83.6 | 148.2 | 194.4 | 230.5 | 260.4 | 287.5 | 300.3 | 310.0 | 324.0 | | | 25 | 85 |
| 1978 | 14 | 85.9 | 151.8 | 204.5 | 241.6 | 273.6 | 301.6 | 314.0 | 338.0 | | | | 33 | 56 |
| 1979 | | | | | | No | Data | | | | | | 17 | 77 |
| 1980 | 968 | 75.3 | 137.7 | 186.7 | 235.3 | 271.3 | 291.0 | 305.8 | 315.2 | 319.8 | 326.5 | | 42 | 82 |
| 1981 | 913 | 70.6 | 126.0 | 173.4 | 205.4 | 259.5 | 291.8 | 309.4 | 319.6 | 327.0 | 339.0 | | 40 | 77 |
| 1982 | 779 | 73.9 | 130.4 | 183.6 | 234.1 | 272.6 | 298.2 | 314.9 | 320.2 | 327.5 | 324.4 | 336.5 | 33 | 49 |
| 1983 | 639 | 74.9 | 134.6 | 185.5 | 227.1 | 276.2 | 300.3 | 314.5 | 325.5 | 332.0 | 333.0 | 340.0 | 17 | 70 |
| | | | | | | SEXES COMBINED | | | | | | | | |
| 1971 | 127 | 85.7 | 145.5 | 189.4 | 227.1 | 267.5 | 286.5 | 297.0 | 306.0 | | | | 21 | 77 |
| 1972 | 334 | 91.8 | 156.2 | 200.8 | 238.5 | 269.4 | 288.1 | 303.9 | 318.8 | | | | 32 | 114 |
| 1973 | 215 | 87.7 | 149.9 | 196.9 | 236.3 | 271.0 | 290.9 | 302.7 | 317.3 | 309.0 | | | 60 | 187 |
| 1974 | 143 | 90.1 | 151.0 | 200.6 | 247.0 | 273.5 | 295.4 | 313.2 | 325.0 | 324.0 | | | 96 | 122 |
| 1975 | 208 | 82.8 | 135.4 | 179.7 | 214.1 | 258.7 | 276.2 | 296.0 | | | | | 45 | 94 |
| 1976 | 246 | 81.0 | 141.3 | 190.1 | 228.9 | 259.9 | 289.5 | 305.9 | 318.1 | 321.4 | 304.0 | | 37 | 61 |
| 1977 | 186 | 83.2 | 142.4 | 183.6 | 218.6 | 251.7 | 278.7 | 298.2 | 309.7 | 320.8 | 318.0 | 324.0 | 25 | 85 |
| 1978 | 202 | 84.2 | 149.2 | 194.1 | 225.7 | 256.8 | 295.1 | 311.4 | 321.3 | 339.0 | | | 33 | 56 |
| 1979 | | | | | | No | Data | | | | | | 17 | 77 |
| 980 | 1409 | 75.8 | 137.3 | 183.2 | 223.4 | 266.3 | 288.8 | 304.3 | 313.5 | 319.8 | 326.5 | | 42 | 82 |
| 1981 | 2398 | 71.5 | 127.5 | 173.3 | 199.7 | 247.0 | 282.2 | 302.4 | 314.9 | 316.0 | 339.0 | | 40 | 77 |
| 1982 | 1894 | 72.9 | 128.2 | 177.7 | 208.4 | 256.1 | 295.9 | 312.8 | 319.5 | 326.3 | 324.1 | 336.5 | 33 | 49 |
| 1983 | 1346 | 73.7 | 131.2 | 177.8 | 208.6 | 269.4 | 299.5 | 316.2 | 327.0 | 334.4 | 333.0 | 340.0 | 17 | 70 |

Table 4.3-28. Weighted mean backcalculated fork lengths (mm) and indices of spawning stock size for rock bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1974-1983).

| YEAR OF CAPTURE | N | AGE (Years) | | | | | | | | | | | SPAWNING STOCK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | Σ IV+ |
| | | | | | | MALES | | | | | | | |
| 1980 | 789 | 52.3 | 91.2 | 135.9 | 176.0 | 207.7 | 229.7 | 243.8 | 254.0 | 257.7 | 261.9 | 289.0 | 7.1 |
| 1981 | 909 | 53.6 | 87.3 | 129.2 | 167.8 | 203.3 | 226.0 | 240.3 | 247.6 | 254.2 | 260.0 | | 1.9 |
| 1982 | 513 | 53.5 | 88.5 | 133.1 | 174.9 | 210.4 | 231.9 | 249.9 | 261.5 | 269.4 | 275.1 | 274.5 | 23.0 |
| 1983 | 853 | 53.3 | 86.9 | 129.1 | 169.5 | 204.7 | 225.2 | 243.8 | 256.8 | 264.2 | 269.5 | 274.5 | 34.8 |
| | | | | | | FEMALES | | | | | | | |
| 1980 | 504 | 52.1 | 89.1 | 131.2 | 166.5 | 194.3 | 214.6 | 227.0 | 237.5 | 243.7 | 256.5 | | 7.1 |
| 1981 | 663 | 54.0 | 86.6 | 126.3 | 162.1 | 192.8 | 212.5 | 228.2 | 242.7 | 247.8 | 255.0 | | 1.9 |
| 1982 | 339 | 53.3 | 86.7 | 128.6 | 167.3 | 198.0 | 219.8 | 234.8 | 246.7 | 255.0 | 258.5 | | 23.0 |
| 1983 | 460 | 52.8 | 85.3 | 125.2 | 163.6 | 194.9 | 212.4 | 229.4 | 239.8 | 247.1 | 255.3 | 256.0 | 34.8 |
| | | | | | | SEXES COMBINED | | | | | | | |
| 1974 | 97 | 52.0 | 88.1 | 132.5 | 173.6 | 203.6 | 225.4 | 241.7 | 254.1 | 279.0 | | | 56.4 |
| 1975 | 171 | 56.1 | 92.1 | 133.9 | 171.9 | 199.9 | 221.0 | 237.2 | 248.3 | 257.4 | | | 19.9 |
| 1976 | 114 | 53.9 | 89.7 | 131.5 | 170.2 | 198.4 | 218.8 | 236.2 | 244.7 | 256.6 | 266.5 | | 57.9 |
| 1977 | 134 | 54.5 | 90.1 | 129.8 | 165.2 | 193.6 | 216.5 | 233.4 | 250.7 | 257.9 | 264.7 | 273.5 | 26.1 |
| 1978 | 98 | 53.6 | 88.6 | 126.9 | 162.6 | 192.7 | 215.4 | 233.4 | 244.1 | 260.2 | | | 82.5 |
| 1979 | | | | | | No Data | | | | | | | |
| 1980 | 1316 | 52.2 | 90.3 | 133.9 | 172.2 | 202.4 | 223.7 | 237.3 | 247.4 | 252.1 | 253.0 | 289.0 | 7.1 |
| 1981 | 2570 | 53.6 | 88.0 | 129.8 | 168.5 | 200.9 | 221.7 | 235.9 | 244.9 | 251.9 | 258.1 | | 1.9 |
| 1982 | 1586 | 53.5 | 88.1 | 131.3 | 171.8 | 204.6 | 227.0 | 243.4 | 254.2 | 262.8 | 267.8 | 275.4 | 23.0 |
| 1983 | 1932 | 53.1 | 86.1 | 127.6 | 167.3 | 200.7 | 219.8 | 237.1 | 247.0 | 255.3 | 262.4 | 270.8 | 34.8 |

Table 4.3-29. Comparative calculated fork lengths (mm) of yellow perch at age in various North American waters.

| LOCATION | SEX | MEAN BACKCALCULATED FORK LENGTH (mm) AT ANNULUS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII | IX | X | XI |
| Sunfish Lake[1] | Combined | 91.9 | 133.3 | 143.2 | 154.7 | 158.4 | 189.6 | | | | | |
| Killarney Lake[1] | Combined | 72.8 | 137.9 | 145.5 | 153.7 | 172.1 | 198.6 | | | | | |
| George Lake[1] | Combined | 75.7 | 133.3 | 142.9 | 153.9 | 165.1 | 182.6 | 180.0 | 178.3 | | | |
| Muriel Lake[1] | Combined | 96.8 | 127.5 | 150.8 | 162.2 | 191.9 | 180.0 | 212.9 | 203.1 | | | |
| South Bay,[2] Lake Huron | Females | 67.1 | 121.6 | 165.9 | 198.8 | 224.5 | | | | | | |
| South Bay,[3] Lake Huron | Females | 75.0 | 149.0 | 202.0 | 239.0 | 269.0 | | | | | | |
| Lake Huron[4] (Bruce G. Stn.) | Combined | 83.8 | 154.6 | 194.5 | 239.2 | 264.5 | 276.8 | 295.9 | 306.3 | | | |
| Lake Ontario[4] (Pickering G. Stn.) | Combined | 96.7 | 157.4 | 187.0 | 203.5 | 233.6 | 249.9 | 253.9 | 253.5 | 268.6 | | |
| Lake Ontario[4] (Lennox G. Stn.) | Combined | 89.5 | 119.8 | 150.4 | 171.0 | 182.4 | 190.8 | 193.7 | 206.7 | 253.0 | | |
| Lake Huron,[5] Saginaw Bay | Combined | 69.0 | 126.4 | 191.3 | 231.2 | 258.6 | 291.1 | 313.5 | | | | |
| Green Bay,[5] Lake Michigan | Combined | 64.0 | 108.9 | 149.3 | 186.3 | 213.7 | 246.1 | 268.6 | | | | |
| Lake Michigan[5] | Combined | 64.0 | 106.5 | 143.9 | 171.3 | 206.3 | 236.2 | | | | | |
| Lake Erie[5] | Combined | 84.0 | 161.4 | 206.3 | 233.6 | 251.0 | | | | | | |
| Red Deer Lake[6] | Males | 56.3 | 90.5 | 117.7 | 149.4 | 176.9 | 205.5 | | | | | |
| | Females | 58.2 | 98.5 | 137.6 | 180.0 | 229.4 | | | | | | |
| Long Point Bay,[7] Lake Erie | Males | 81.2 | 139.8 | 178.7 | 204.4 | 231.5 | 267.2 | 292.4 | 307.6 | | | |
| | Females | 82.3 | 144.7 | 194.6 | 234.3 | 269.3 | 293.4 | 310.2 | 321.4 | 324.6 | 330.7 | 338.3 |
| | Combined | 81.7 | 141.3 | 187.0 | 223.0 | 242.7 | 288.9 | 305.3 | 317.4 | 323.6 | 324.1 | 327.2 |
| Long Point Bay,[8] Lake Erie | Males | 71.0 | 123.8 | 162.3 | 181.3 | 206.8 | 252.3 | 321.0 | 328.0 | | | |
| | Females | 74.9 | 134.6 | 185.5 | 227.1 | 276.2 | 300.3 | 314.5 | 325.5 | 332.0 | 333.0 | 340.0 |
| | Combined | 73.7 | 131.2 | 177.8 | 208.6 | 269.4 | 299.5 | 316.2 | 327.0 | 334.4 | 333.0 | 340.0 |

[1] Ryan and Harvey (1980) [2] Henderson (1985): mean of all year classes presented [3] Henderson (1985): 1972 year class [4] Griffiths (1978 b)
[5] Van Oosten (1948) [6] Chadwick (1975) [7] Grand mean from all collection years (1971-1983) [8] Data from 1983 collection year

Table 4.3-30. Comparative calculated fork lengths (mm) of rock bass at age in various North American waters.

| LOCATION | SEX | MEAN BACKCALCULATED FORK LENGTH (mm) AT ANNULUS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII | IX | X | XI |
| Silver Lake,[1] Wisconsin | Females<br>Males | 36.1<br>36.1 | 56.1<br>56.1 | 78.9<br>80.8 | 100.7<br>103.6 | 129.2<br>136.8 | 153.9<br>164.4 | 177.7<br>191.9 | 200.5<br>208.1 | 210.0<br>216.6 | | |
| Muskellunge Lake,[1] Wisconsin | Females<br>Males | 38.0<br>38.0 | 59.9<br>59.9 | 79.8<br>80.8 | 100.7<br>101.7 | 119.7<br>124.5 | 137.8<br>143.5 | 156.8<br>165.3 | 170.1<br>181.5 | 185.3<br>199.5 | 196.7<br>209.0 | 208.1<br>216.6 |
| Nebish Lake,[1] Wisconsin | Females<br>Males | 39.0<br>39.9 | 72.2<br>72.2 | 103.6<br>105.5 | 130.2<br>137.8 | 151.1<br>161.5 | 164.4<br>176.7 | 173.9<br>188.1 | 180.5<br>197.6 | 188.1<br>205.2 | 193.8<br>213.8 | 201.4<br>222.3 |
| Black River,[1] Montana | Combined | 38.0 | 72.2 | 113.1 | 144.4 | 175.8 | 175.8 | | | | | |
| Tippecanoe River,[1] Indiana | Combined | 43.7 | 77.9 | 123.5 | 164.4 | 192.9 | 200.5 | | | | | |
| Little Miami River,[1] Ohio | Combined | 39.9 | 75.1 | 125.4 | 164.4 | 188.1 | 200.5 | 210.0 | | | | |
| Massie Creek,[1] Ohio | Combined | 40.9 | 79.8 | 128.3 | 161.5 | 180.5 | 195.7 | 202.4 | | | | |
| Charlton Lake,[2] Ontario | Combined | 35.7 | 59.1 | 82.2 | 104.3 | 129.0 | 145.5 | 155.9 | | 216.6 | | |
| Gem Lake,[2] Ontario | Combined | 37.5 | 65.7 | 83.6 | 104.1 | 122.9 | 136.9 | 146.4 | 159.2 | 183.6 | 180.5 | |
| Florence Lake,[2] Ontario | Combined | 35.1 | 61.5 | 80.7 | 91.0 | 102.5 | 110.9 | 123.2 | 138.2 | 157.5 | | |
| La Cloche Lakes[2] Combined, Ontario | Combined | 36.5 | 64.4 | 92.1 | 101.8 | 127.6 | 135.7 | 151.7 | 167.0 | 188.1 | 185.0 | 205.0 |
| Nanticoke,[3] Long Point Bay, Lake Erie | Females<br>Males<br>Combined | 52.8<br>53.3<br>53.1 | 85.3<br>86.9<br>86.1 | 125.2<br>129.1<br>127.6 | 163.6<br>169.5<br>167.3 | 194.9<br>204.7<br>200.7 | 212.4<br>225.2<br>219.8 | 229.4<br>243.8<br>237.1 | 239.8<br>256.8<br>247.0 | 247.1<br>264.2<br>255.3 | 255.3<br>269.5<br>262.4 | 256.0<br>274.5<br>270.8 |
| Nanticoke,[4] Long Point Bay, Lake Erie | Females<br>Males<br>Combined | 53.1<br>53.2<br>53.1 | 87.0<br>88.5<br>88.1 | 127.8<br>131.8<br>130.7 | 164.9<br>172.1<br>170.0 | 195.0<br>206.5<br>202.2 | 214.8<br>228.7<br>223.1 | 229.9<br>244.4<br>238.4 | 241.7<br>255.0<br>248.4 | 248.4<br>261.9<br>255.3 | 256.3<br>266.6<br>260.3 | <br>279.3<br>278.4 |

[1] Carlander (1977) [2] Ryan and Harvey (1977) [3] Data from 1983 collection year [4] Data are means of 1980-1983 collection years

Table 4.3-31. Comparative fork lengths (mm) of smallmouth bass at age in various North American waters.

| | | MEAN BACKCALCULATED FORK LENGTH (mm) AT ANNULUS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOCATION | SEX | I | II | III | IV | V | VI | VII | VIII | IX | X | XI |
| Waugoshance Point,[1] Lake Michigan | Combined | 104.6 | 150.7 | 180.5 | 212.2 | 256.3 | 297.6 | 343.7 | 380.2 | 407.0 | 424.3 | 433.9 |
| Hog Island,[1] Lake Michigan | Combined | 109.4 | 144.0 | 180.5 | 212.2 | 256.3 | 297.6 | 341.8 | 380.2 | 394.6 | 414.7 | 432.0 |
| South Bay,[1] Lake Huron | Combined | 106.6 | 147.8 | 224.6 | 256.3 | 281.3 | 313.0 | 341.8 | | | | |
| Oneida Lake,[1] New York | Combined | 95.0 | 168.0 | 239.0 | 299.5 | 329.3 | 358.1 | 383.0 | 400.3 | 407.0 | 416.6 | |
| **Massie** Creek,[1] Ohio | Combined | 73.0 | 139.2 | 207.4 | 263.0 | 302.4 | 337.0 | 358.1 | 368.6 | | | |
| Norris Lake,[1] Tennessee | Combined | 135.4 | 260.2 | 348.5 | | | | | | | | |
| Little Lake,[1] Oklahoma | Combined | 90.2 | 182.4 | 236.2 | 278.4 | 324.5 | 356.2 | | | | | |
| Clearwater River,[1] Idaho | Combined | 79.7 | 136.3 | 185.3 | 231.4 | 258.2 | 283.2 | 302.4 | 312.0 | 324.5 | | |
| Lower Snake River,[1] Idaho | Combined | 80.6 | 139.2 | 197.8 | 229.4 | 256.3 | 280.3 | 297.6 | 309.1 | | | |
| Red Cedar River,[1] Wisconsin | Combined | 96.0 | 182.4 | 263.0 | 315.8 | 367.7 | 390.7 | 407.0 | 426.2 | | | |
| Des Moines River,[1] Indiana | Combined | 114.2 | 219.8 | 285.1 | 326.4 | 372.5 | 394.6 | | | | | |
| Long Point Bay,[2] Lake Erie | Combined | 99.2 | 172.9 | 217.4 | 274.8 | 311.5 | 350.8 | 380.8 | 405.2 | 417.5 | | |

[1] Carlander (1977) [2] Data from the 1962 collection year

Table 4.3-32. Comparative calculated fork lengths (mm) of white bass at age in various North American waters.

| LOCATION | SEX | MEAN BACKCALCULATED FORK LENGTH (mm) AT ANNULUS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII | IX |
| Oneida Lake,[1] New York | Males | 120.7 | 241.2 | 281.4 | 305.0 | 316.8 | 328.6 | 347.5 | 352.2 | |
| | Females | 123.1 | 245.9 | 300.2 | 319.1 | 335.7 | 345.1 | 361.6 | | |
| | Combined | 125.4 | 243.5 | 290.8 | 314.4 | 330.9 | 347.5 | 364.0 | 378.2 | 411.3 |
| Buckeye Lake,[2] Oregon | Combined | 141.9 | 236.4 | 307.3 | | | | | | |
| Norris Reservoir,[2] (TVA) | Combined | 149.0 | 248.3 | 288.4 | | | | | | |
| Lake Erie[2] | Combined | 111.3 | 194.0 | 257.7 | 293.2 | 312.1 | 321.4 | 330.9 | | |
| Lewis & Clark Lake,[3] Nebraska | Males | 97.9 | 213.2 | 263.4 | 286.7 | 314.6 | 325.7 | | | |
| | Females | 102.5 | 231.8 | 286.7 | 313.6 | 343.4 | 352.7 | | | |
| | Combined | 100.7 | 222.5 | 276.4 | 300.6 | 328.5 | 336.9 | | | |
| Long Point Bay,[4] Lake Erie | Combined | 123.0 | 212.8 | 274.7 | | | | | | |

[1] Forney and Taylor (1963)

[2] Van Oosten (1948)

[3] Ruelle (1971)

[4] Mean of 1980-1983 catches

Table 4.3-33. Mean backcalculated fork lengths (mm) at annulus for combined sexes of rock bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1980-1983).

| | | | | MEAN BACKCALCULATED FORK LENGTH AT ANNULUS (mm) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR OF CAPTURE | AGE | YEAR CLASS | N | I | II | III | IV | V | VI | VII | VII | IX | X | XI |
| 1980 | II | 1978 | 12 | 54.9 | 103.1 | | | | | | | | | |
| | III | 1977 | 309 | 53.3 | 90.9 | 134.2 | | | | | | | | |
| | IV | 1976 | 162 | 52.6 | 94.3 | 139.1 | 176.6 | | | | | | | |
| | V | 1975 | 216 | 52.3 | 91.4 | 136.6 | 176.5 | 204.9 | | | | | | |
| | VI | 1974 | 182 | 52.1 | 91.3 | 134.9 | 175.3 | 208.3 | 228.9 | | | | | |
| | VII | 1973 | 226 | 51.9 | 88.4 | 133.0 | 170.7 | 202.3 | 224.5 | 238.9 | | | | |
| | VIII | 1972 | 147 | 51.3 | 86.8 | 127.9 | 165.2 | 196.9 | 220.2 | 237.5 | 249.4 | | | |
| | IX | 1971 | 53 | 49.9 | 84.4 | 124.8 | 160.8 | 191.0 | 215.5 | 232.9 | 243.9 | 253.2 | | |
| | X | 1970 | 8 | 46.1 | 80.6 | 119.1 | 154.3 | 183.3 | 203.6 | 219.8 | 235.3 | 244.1 | 250.1 | |
| | XI | 1969 | 1 | 40.0 | 67.0 | 94.0 | 117.0 | 167.0 | 199.0 | 220.0 | 235.0 | 256.0 | 275.0 | 289.0 |
| Weighted Mean Backcalculated Fork Length (mm): | | | | 52.2 | 90.3 | 133.9 | 172.2 | 202.4 | 223.7 | 237.3 | 247.4 | 252.1 | 252.9 | 289.0 |
| | | | N: | 1316 | 1316 | 1304 | 995 | 833 | 617 | 435 | 209 | 62 | 9 | 1 |
| 1981 | II | 1979 | 10 | 55.1 | 95.5 | | | | | | | | | |
| | III | 1978 | 302 | 55.0 | 91.1 | 133.7 | | | | | | | | |
| | IV | 1977 | 1429 | 53.8 | 87.3 | 129.0 | 168.3 | | | | | | | |
| | V | 1976 | 260 | 53.4 | 90.8 | 134.0 | 173.1 | 203.2 | | | | | | |
| | VI | 1975 | 229 | 53.3 | 90.7 | 134.4 | 175.5 | 207.1 | 224.6 | | | | | |
| | VII | 1974 | 120 | 52.2 | 85.5 | 125.9 | 166.8 | 201.8 | 226.0 | 240.3 | | | | |
| | VIII | 1973 | 106 | 52.2 | 84.3 | 124.6 | 160.7 | 195.8 | 220.3 | 236.8 | 246.6 | | | |
| | IX | 1972 | 92 | 50.7 | 83.0 | 118.8 | 154.7 | 187.0 | 212.9 | 230.7 | 243.6 | 251.9 | | |
| | X | 1971 | 16 | 51.8 | 80.8 | 119.3 | 156.1 | 188.4 | 210.1 | 229.9 | 242.7 | 252.0 | 258.1 | |
| | XI | 1970 | 3 | 46.7 | 76.3 | 116.3 | 146.3 | 175.7 | 201.0 | 218.7 | 234.7 | 250.0 | 258.3 | |
| Weighted Mean Backcalculated Fork Length (mm): | | | | 53.6 | 88.0 | 129.8 | 168.5 | 200.9 | 221.7 | 235.9 | 244.9 | 251.9 | 258.1 | |
| | | | N: | 2570 | 2570 | 2560 | 2255 | 826 | 566 | 337 | 217 | 111 | 19 | |
| 1982 | II | 1980 | 12 | 54.7 | 98.8 | | | | | | | | | |
| | III | 1979 | 63 | 53.6 | 90.9 | 139.8 | | | | | | | | |
| | IV | 1978 | 281 | 54.5 | 91.0 | 136.1 | 179.2 | | | | | | | |
| | V | 1977 | 754 | 53.3 | 86.2 | 128.2 | 169.2 | 204.5 | | | | | | |
| | VI | 1976 | 186 | 54.2 | 91.0 | 134.2 | 173.8 | 205.9 | 226.2 | | | | | |
| | VII | 1975 | 104 | 52.7 | 89.5 | 134.9 | 175.6 | 208.1 | 230.1 | 245.0 | | | | |
| | VIII | 1974 | 101 | 53.0 | 88.6 | 132.6 | 172.2 | 206.4 | 229.4 | 245.0 | 255.1 | | | |
| | IX | 1973 | 45 | 51.8 | 84.8 | 126.0 | 165.0 | 200.0 | 225.0 | 242.3 | 255.4 | 264.6 | | |
| | X | 1972 | 29 | 51.2 | 83.1 | 122.1 | 157.2 | 191.8 | 218.8 | 236.8 | 250.3 | 259.9 | 266.8 | |
| | IX | 1971 | 11 | 52.0 | 83.4 | 121.9 | 156.6 | 191.5 | 218.6 | 236.7 | 251.8 | 262.8 | 270.6 | 275.4 |
| Weighted Mean Backcalculated Fork Length (mm): | | | | 53.5 | 88.1 | 131.3 | 171.8 | 204.6 | 227.0 | 243.4 | 254.2 | 262.8 | 267.8 | 275.4 |
| | | | N: | 1586 | 1586 | 1574 | 1511 | 1230 | 476 | 290 | 186 | 85 | 40 | 11 |
| 1983 | II | 1981 | 2 | 61.0 | 103.0 | | | | | | | | | |
| | III | 1980 | 50 | 53.5 | 93.8 | 136.9 | | | | | | | | |
| | IV | 1979 | 182 | 53.2 | 90.1 | 134.8 | 172.6 | | | | | | | |
| | V | 1978 | 634 | 53.5 | 85.8 | 128.2 | 171.0 | 202.1 | | | | | | |
| | VI | 1977 | 881 | 53.0 | 84.9 | 124.7 | 163.5 | 200.1 | 219.4 | | | | | |
| | VII | 1976 | 72 | 52.8 | 89.5 | 132.9 | 172.4 | 203.3 | 226.5 | 240.0 | | | | |
| | VIII | 1975 | 50 | 52.1 | 87.2 | 129.3 | 167.7 | 199.8 | 221.9 | 237.7 | 248.2 | | | |
| | IX | 1974 | 27 | 51.5 | 85.0 | 127.1 | 163.3 | 195.7 | 218.6 | 234.3 | 246.7 | 254.9 | | |
| | X | 1973 | 30 | 51.5 | 83.1 | 124.8 | 159.5 | 191.6 | 215.7 | 233.0 | 245.7 | 255.4 | 261.9 | |
| | XI | 1972 | 4 | 48.8 | 84.3 | 119.3 | 151.5 | 180.5 | 203.8 | 226.8 | 244.8 | 256.5 | 265.8 | 270.8 |
| Weighted Mean Backcalculated Fork Length (mm): | | | | 53.1 | 86.1 | 127.6 | 167.3 | 200.7 | 219.8 | 237.1 | 247.0 | 255.3 | 262.4 | 270.8 |
| | | | N: | 1932 | 1932 | 1930 | 1880 | 1698 | 1064 | 183 | 111 | 61 | 34 | 4 |

Table 4.3-34. Mean backcalculated fork lengths (mm) at annulus for combined sexes of yellow perch captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie, (1980-1983).

| | | | | MEAN BACKCALCULATED FORK LENGTH AT ANNULUS (mm) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR OF CAPTURE | AGE | YEAR CLASS | N | I | II | III | IV | V | VI | VII | VIII | IX | X | XI |
| 1980 | II | 1978 | 215 | 81.7 | 144.4 | | | | | | | | | |
| | III | 1977 | 913 | 74.1 | 136.0 | 181.6 | | | | | | | | |
| | IV | 1976 | 131 | 72.4 | 129.4 | 178.5 | 207.3 | | | | | | | |
| | V | 1975 | 48 | 81.0 | 146.1 | 201.1 | 239.4 | 264.9 | | | | | | |
| | VI | 1974 | 29 | 80.6 | 142.6 | 199.2 | 240.6 | 269.2 | 288.8 | | | | | |
| | VII | 1973 | 31 | 80.9 | 141.8 | 198.6 | 240.9 | 272.8 | 294.4 | 308.0 | | | | |
| | VIII | 1972 | 22 | 78.5 | 138.1 | 193.7 | 234.8 | 264.8 | 287.7 | 304.5 | 316.5 | | | |
| | IX | 1971 | 14 | 80.8 | 135.4 | 188.1 | 227.9 | 256.7 | 280.6 | 298.4 | 310.1 | 320.1 | | |
| | X | 1970 | 4 | 78.3 | 136.8 | 187.3 | 223.0 | 254.3 | 280.0 | 295.8 | 309.0 | 318.8 | 326.5 | |
| Weighted Mean Backcalculated Fork Length (mm): | | | | 75.8 | 137.3 | 183.2 | 223.4 | 266.3 | 288.8 | 304.3 | 313.5 | 319.8 | 326.5 | |
| | | | N: | 1409 | 1407 | 1192 | 279 | 148 | 100 | 71 | 40 | 18 | 4 | |
| 1981 | II | 1979 | 588 | 71.7 | 134.4 | | | | | | | | | |
| | III | 1978 | 1068 | 72.5 | 126.7 | 175.6 | | | | | | | | |
| | IV | 1977 | 613 | 69.2 | 121.6 | 166.6 | 195.2 | | | | | | | |
| | V | 1976 | 56 | 68.9 | 124.3 | 175.4 | 206.9 | 227.4 | | | | | | |
| | VI | 1975 | 35 | 75.5 | 136.7 | 192.0 | 233.3 | 259.8 | 276.5 | | | | | |
| | VII | 1974 | 15 | 74.1 | 134.0 | 188.3 | 235.1 | 266.7 | 285.6 | 297.7 | | | | |
| | VIII | 1973 | 16 | 74.0 | 132.6 | 186.8 | 232.2 | 267.8 | 293.3 | 308.7 | 316.9 | | | |
| | IX | 1972 | 4 | 69.8 | 126.8 | 179.0 | 219.3 | 248.3 | 274.3 | 294.8 | 305.0 | 311.5 | | |
| | X | 1971 | 1 | 75.0 | 150.0 | 206.0 | 239.0 | 264.0 | 286.0 | 304.0 | 323.0 | 334.0 | 339.0 | |
| Weighted Mean Backcalculated Fork Length (mm): | | | | 71.5 | 127.5 | 173.1 | 199.7 | 247.0 | 282.2 | 302.4 | 314.9 | 316.0 | 339.0 | |
| | | | N: | 2398 | 2396 | 1808 | 740 | 127 | 71 | 36 | 21 | 5 | 1 | |
| 1982 | II | 1980 | 119 | 86.1 | 148.4 | | | | | | | | | |
| | III | 1979 | 1229 | 71.1 | 127.0 | 178.9 | | | | | | | | |
| | IV | 1978 | 355 | 72.8 | 120.7 | 166.7 | 197.5 | | | | | | | |
| | V | 1977 | 99 | 76.3 | 135.3 | 182.3 | 216.3 | 240.7 | | | | | | |
| | VI | 1976 | 24 | 75.6 | 140.9 | 200.1 | 242.6 | 271.1 | 294.5 | | | | | |
| | VII | 1975 | 26 | 80.2 | 149.6 | 212.8 | 255.7 | 285.6 | 306.8 | 319.9 | | | | |
| | VIII | 1974 | 18 | 76.6 | 134.4 | 194.2 | 240.5 | 273.6 | 297.7 | 313.9 | 323.1 | | | |
| | IX | 1973 | 15 | 74.5 | 136.4 | 189.9 | 232.7 | 263.9 | 288.7 | 308.6 | 321.3 | 331.1 | | |
| | X | 1972 | 7 | 72.7 | 128.4 | 177.9 | 219.9 | 251.0 | 276.4 | 296.3 | 308.4 | 316.6 | 322.0 | |
| | XI | 1971 | 2 | 63.5 | 127.0 | 186.0 | 225.5 | 255.5 | 279.0 | 299.0 | 314.5 | 324.0 | 331.5 | 336.5 |
| Weighted Mean Backcalculated Fork Length (mm): | | | | 72.9 | 128.2 | 177.7 | 208.4 | 256.1 | 295.9 | 312.8 | 319.5 | 326.3 | 324.1 | 336.5 |
| | | | N: | 1894 | 1894 | 1775 | 546 | 191 | 92 | 68 | 42 | 24 | 9 | 2 |
| 1983 | II | 1981 | 314 | 76.3 | 136.3 | | | | | | | | | |
| | III | 1980 | 478 | 74.9 | 133.1 | 179.3 | | | | | | | | |
| | IV | 1979 | 387 | 68.2 | 119.3 | 168.3 | 195.6 | | | | | | | |
| | V | 1978 | 58 | 74.8 | 132.7 | 184.8 | 225.9 | 252.0 | | | | | | |
| | VI | 1977 | 48 | 79.4 | 147.0 | 201.1 | 246.0 | 279.3 | 297.9 | | | | | |
| | VII | 1976 | 22 | 79.4 | 141.4 | 199.9 | 243.1 | 276.3 | 300.0 | 315.3 | | | | |
| | VIII | 1975 | 23 | 79.7 | 142.6 | 203.8 | 248.2 | 281.1 | 302.4 | 317.4 | 327.5 | | | |
| | IX | 1974 | 12 | 79.9 | 142.2 | 197.4 | 244.8 | 279.2 | 303.1 | 318.9 | 328.8 | 336.8 | | |
| | X | 1973 | 2 | 76.5 | 148.0 | 205.0 | 242.0 | 272.5 | 292.5 | 307.0 | 319.5 | 326.5 | 331.0 | |
| | XI | 1972 | 2 | 77.5 | 128.5 | 188.5 | 227.0 | 262.0 | 286.5 | 306.0 | 318.5 | 328.0 | 335.0 | 340.0 |
| Weighted Mean Backcalculated Fork Length (mm): | | | | 73.7 | 131.2 | 177.8 | 208.6 | 269.4 | 299.5 | 316.2 | 327.0 | 334.4 | 333.0 | 340.0 |
| | | | N: | 1346 | 1346 | 1032 | 554 | 167 | 109 | 61 | 39 | 16 | 4 | 2 |

Table 4.3-35. Mean backcalculated fork lengths (mm) at annulus for combined sexes of smallmouth bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1980-1983).

| YEAR OF CAPTURE | AGE | YEAR CLASS | N | AGE<br>I | II | III | IV | V | VI | VII | VIII | IX | X | XI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | II | 1978 | 12 | 101.9 | 173.2 | | | | | | | | | |
| | III | 1977 | 44 | 96.1 | 158.1 | 213.5 | | | | | | | | |
| | IV | 1976 | 6 | 92.2 | 160.8 | 235.2 | 301.7 | | | | | | | |
| | V | 1975 | 5 | 94.6 | 160.4 | 229.6 | 283.4 | 322.8 | | | | | | |
| | VI | 1974 | 4 | 93.5 | 169.3 | 226.3 | 277.5 | 318.5 | 354.8 | | | | | |
| | VII | 1973 | 3 | 95.3 | 153.3 | 223.7 | 273.7 | 328.0 | 363.7 | 386.7 | | | | |
| | VIII | 1972 | 2 | 89.5 | 166.0 | 216.5 | 269.5 | 308.5 | 351.5 | 385.0 | 414.5 | | | |
| Weighted Mean Backcalculated Fork Length (mm): | | | | 96.3 | 161.5 | 218.2 | 284.9 | 320.6 | 357.0 | 386.0 | 414.5 | | | |
| | | | N: | 76 | 76 | 64 | 20 | 14 | 9 | 5 | 2 | | | |
| 1981 | II | 1979 | 19 | 94.2 | 165.8 | | | | | | | | | |
| | III | 1978 | 82 | 96.6 | 156.1 | 216.1 | | | | | | | | |
| | IV | 1977 | 37 | 90.8 | 153.6 | 206.0 | 260.6 | | | | | | | |
| | V | 1976 | 6 | 87.8 | 154.0 | 211.5 | 262.7 | 313.0 | | | | | | |
| | VI | 1975 | 1 | 94.0 | 155.0 | 215.0 | 263.0 | 299.0 | 333.0 | | | | | |
| | VIII | 1973 | 2 | 90.0 | 157.5 | 207.0 | 257.5 | 305.0 | 359.0 | 395.0 | 415.0 | | | |
| Weighted Mean Backcalculated Fork Length (mm): | | | | 94.4 | 156.7 | 212.8 | 260.8 | 309.7 | 350.3 | 395.0 | 415.0 | | | |
| | | | N: | 147 | 147 | 128 | 46 | 9 | 3 | 2 | 2 | | | |
| 1982 | II | 1980 | 114 | 102.5 | 187.7 | | | | | | | | | |
| | III | 1979 | 13 | 94.0 | 162.2 | 235.7 | | | | | | | | |
| | IV | 1978 | 51 | 97.4 | 157.0 | 221.4 | 285.8 | | | | | | | |
| | V | 1977 | 19 | 94.5 | 152.4 | 204.8 | 257.9 | 310.0 | | | | | | |
| | VI | 1976 | 9 | 87.7 | 148.6 | 207.2 | 258.7 | 313.4 | 349.3 | | | | | |
| | VII | 1975 | 4 | 92.8 | 143.0 | 210.5 | 273.8 | 316.5 | 353.5 | 380.5 | | | | |
| | VIII | 1974 | 1 | 105.0 | 165.0 | 222.0 | 278.0 | 326.0 | 361.0 | 392.0 | 419.0 | | | |
| | IX | 1973 | 2 | 82.0 | 145.5 | 200.0 | 254.5 | 293.5 | 339.0 | 373.0 | 397.5 | 416.5 | | |
| | XI | 1971 | 1 | 79.0 | 129.0 | 187.0 | 239.0 | 279.0 | 322.0 | 353.0 | 380.0 | 397.0 | 414.0 | 425.0 |
| Weighted Mean Backcalculated Fork Length (mm): | | | | 99.0 | 172.4 | 217.6 | 275.0 | 310.2 | 348.2 | 376.6 | 398.5 | 410.0 | 414.0 | 425.0 |
| | | | N: | 214 | 214 | 100 | 87 | 36 | 17 | 8 | 4 | 3 | 1 | 1 |
| 1983 | II | 1981 | 12 | 108.8 | 166.1 | | | | | | | | | |
| | III | 1980 | 32 | 103.4 | 188.8 | 247.2 | | | | | | | | |
| | IV | 1979 | 23 | 97.7 | 176.0 | 251.2 | 297.7 | | | | | | | |
| | V | 1978 | 15 | 92.9 | 149.1 | 208.3 | 273.8 | 317.8 | | | | | | |
| | VI | 1977 | 6 | 92.8 | 158.0 | 219.2 | 273.2 | 324.2 | 357.3 | | | | | |
| Weighted Mean Backcalculated Fork Length (mm): | | | | 100.1 | 173.5 | 238.5 | 286.2 | 319.6 | 357.3 | | | | | |
| | | | N: | 88 | 88 | 76 | 44 | 21 | 6 | | | | | |

Table 4.3-36. Mean backcalculated fork lengths (mm) at annulus for combined sexes of white bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1980-1983).

|  |  |  |  | MEAN BACKCALCULATED FORK LENGTH AT ANNULUS (mm) |  |  |
|---|---|---|---|---|---|---|
| YEAR OF CAPTURE | AGE | YEAR CLASS | N | I | II | III |
| 1980 | I | 1979 | 13 | 121.3 |  |  |
|  | II | 1978 | 2 | 117.4 | 218.1 |  |
|  | III | 1977 | 1 | 153.0 | 239.0 | 270.0 |
| Weighted Mean Backcalculated Fork Length (mm): |  |  |  | 122.8 | 225.1 | 270.0 |
|  |  |  | N: | 16 | 3 | 1 |
| 1981 | I | 1980 | 764 | 127.5 |  |  |
|  | II | 1979 | 6 | 122.7 | 226.9 |  |
|  | III | 1978 | 2 | 123.6 | 207.1 | 266.5 |
| Weighted Mean Backcalculated Fork Length (mm): |  |  |  | 127.5 | 222.0 | 266.5 |
|  |  |  | N: | 772 | 8 | 2 |
| 1982 | I | 1981 | 192 | 130.2 |  |  |
|  | II | 1980 | 53 | 125.0 | 221.6 |  |
| Weighted Mean Backcalculated Fork Length (mm): |  |  |  | 129.1 | 221.6 |  |
|  |  |  | N: | 245 | 53 |  |
| 1983 | I | 1982 | 30 | 114.3 |  |  |
|  | II | 1981 | 26 | 121.2 | 187.3 |  |
|  | III | 1980 | 1 | 133.4 | 242.8 | 290.5 |
| Weighted Mean Backcalculated Fork Length (mm): |  |  |  | 117.8 | 189.4 | 290.5 |
|  |  |  | N: | 57 | 27 | 1 |

Table 4.3-37. Population ($G_X$) and true (individual, $\bar{G}$) growth rates for yellow perch and rock bass captured at Nanticoke trapnet locations, Long Point, Bay, Lake Erie (1980-1983).

| | | 1981 | | 1982 | | 1983 | |
|---|---|---|---|---|---|---|---|
| **AGE INTERVAL** | **SEX** | $G_X$ | $\bar{G}$ | $G_X$ | $\bar{G}$ | $G_X$ | $\bar{G}$ |
| | | **YELLOW PERCH** | | | | | |
| 2-3 | Males | 0.560 | 0.892 | 0.407 | 0.897 | 0.595 | 0.836 |
| | Females | 0.895 | 1.165 | 0.649 | 1.203 | 0.920 | 1.020 |
| | Combined | 0.831 | 1.079 | 0.620 | 1.128 | 0.859 | 1.010 |
| 3-4 | Males | 0.204 | 0.430 | 0.196 | 0.471 | 0.170 | 0.402 |
| | Females | 0.399 | 0.560 | 0.654 | 0.641 | 0.490 | 0.550 |
| | Combined | 0.329 | 0.524 | 0.328 | 0.558 | 0.288 | 0.509 |
| 4-5 | Males | 0.288 | 0.252 | 0.295 | 0.294 | 0.239 | 0.262 |
| | Females | 0.712 | 0.323 | 0.726 | 0.369 | 0.769 | 0.390 |
| | Combined | 0.474 | 0.312 | 0.656 | 0.352 | 0.838 | 0.370 |
| 5-6 | Males | 0.582 | 0.252 | NO DATA | | 0.416 | 0.153 |
| | Females | 0.578 | 0.200 | 0.255 | 0.277 | 0.385 | 0.209 |
| | Combined | 0.607 | 0.206 | 0.669 | 0.273 | 0.553 | 0.208 |
| | | **ROCK BASS** | | | | | |
| 3-4 | Males | 0.664 | 0.792 | 0.723 | 0.865 | 0.691 | 0.776 |
| | Females | 0.588 | 0.752 | 0.655 | 0.806 | 0.747 | 0.778 |
| | Combined | 0.668 | 0.782 | 0.734 | 0.820 | 0.743 | 0.785 |
| 4-5 | Males | 0.539 | 0.483 | 0.465 | 0.605 | 0.530 | 0.524 |
| | Females | 0.527 | 0.461 | 0.317 | 0.566 | 0.517 | 0.508 |
| | Combined | 0.344 | 0.471 | 0.391 | 0.565 | 0.506 | 0.531 |
| 5-6 | Males | 0.371 | 0.241 | 0.328 | 0.284 | 0.294 | 0.287 |
| | Females | 0.277 | 0.231 | 0.321 | 0.273 | 0.243 | 0.270 |
| | Combined | 0.291 | 0.238 | 0.298 | 0.280 | 0.263 | 0.293 |
| 6-7 | Males | 0.231 | 0.160 | 0.173 | 0.197 | 0.259 | 0.178 |
| | Females | 0.124 | 0.175 | 0.200 | 0.184 | 0.281 | 0.156 |
| | Combined | 0.196 | 0.181 | 0.236 | 0.187 | 0.288 | 0.184 |

Table 4.3-38. Trends in true instantaneous growth rates ($\overline{G}$) across year classes of yellow perch, rock bass and smallmouth bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1971-1983).

| AGE INTERVAL | YEAR CLASS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
| | | | | | | | YELLOW PERCH | | | | | | | | |
| 2-3 | | | | 0.862 | 0.774 | 0.913 | 0.813 | 0.984 | 0.818 | 0.712 | | 0.927 | 1.079 | 1.128 | 1.010 |
| 3-4 | | | 0.359 | 0.350 | 0.474 | 0.495 | 0.457 | 0.476 | 0.376 | | 0.479 | 0.524 | 0.558 | 0.509 | |
| 4-5 | | 0.299 | 0.291 | 0.275 | 0.277 | 0.363 | 0.339 | 0.288 | | 0.324 | 0.312 | 0.352 | 0.370 | | |
| 5-6 | 0.201 | 0.185 | 0.171 | 0.211 | 0.240 | 0.305 | 0.164 | | 0.225 | 0.206 | 0.273 | 0.208 | | | |
| | | | | | | | ROCK BASS | | | | | | | | |
| 3-4 | | | | | | 0.723 | 0.770 | 0.773 | 0.838 | | 0.737 | 0.782 | 0.820 | 0.785 | |
| 4-5 | | | | | 0.407 | 0.443 | 0.468 | 0.499 | | 0.461 | 0.471 | 0.565 | 0.531 | | |
| 5-6 | | | | 0.225 | 0.232 | 0.297 | 0.355 | | 0.291 | 0.238 | 0.280 | 0.293 | | | |
| 6-7 | | | 0.144 | 0.178 | 0.146 | 0.216 | | 0.192 | 0.181 | 0.187 | 0.184 | | | | |
| | | | | | | | SMALLMOUTH BASS | | | | | | | | |
| 2-3 | | | | 0.919 | 0.712 | 1.092 | 0.976 | 0.977 | 0.811 | 0.943 | | 0.920 | 0.991 | 1.178 | 0.880 |
| 3-4 | | | 0.571 | 0.569 | 0.634 | 0.709 | 0.810 | 0.639 | 0.652 | | 0.763 | 0.716 | 0.805 | 0.554 | |
| 4-5 | | 0.440 | 0.346 | 0.337 | 0.339 | 0.462 | 0.427 | 0.491 | | 0.399 | 0.534 | 0.580 | 0.486 | | |
| 5-6 | | 0.241 | 0.380 | | 0.236 | 0.343 | 0.318 | | 0.331 | 0.328 | 0.342 | 0.317 | | | |

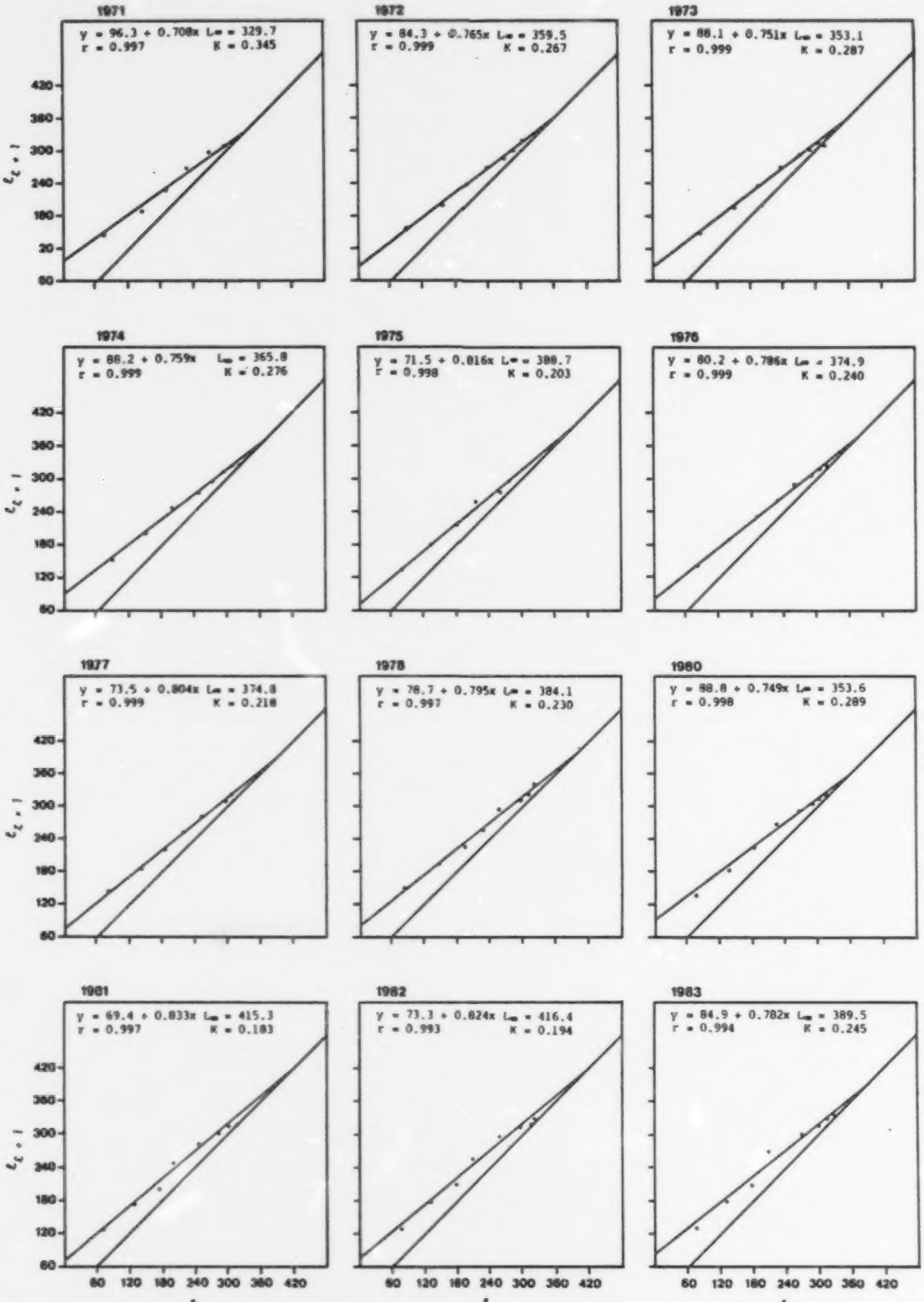


Figure 4.3-1. Walford plots of weighted mean backcalculated fork lengths ($\ell$,mm) at age ($t+1$) against weighted mean backcalculated fork lengths ($\ell$,mm) at age $t$ for combined sexes of yellow perch captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1971-1983). Summarized by year of capture including age groups 1-8.

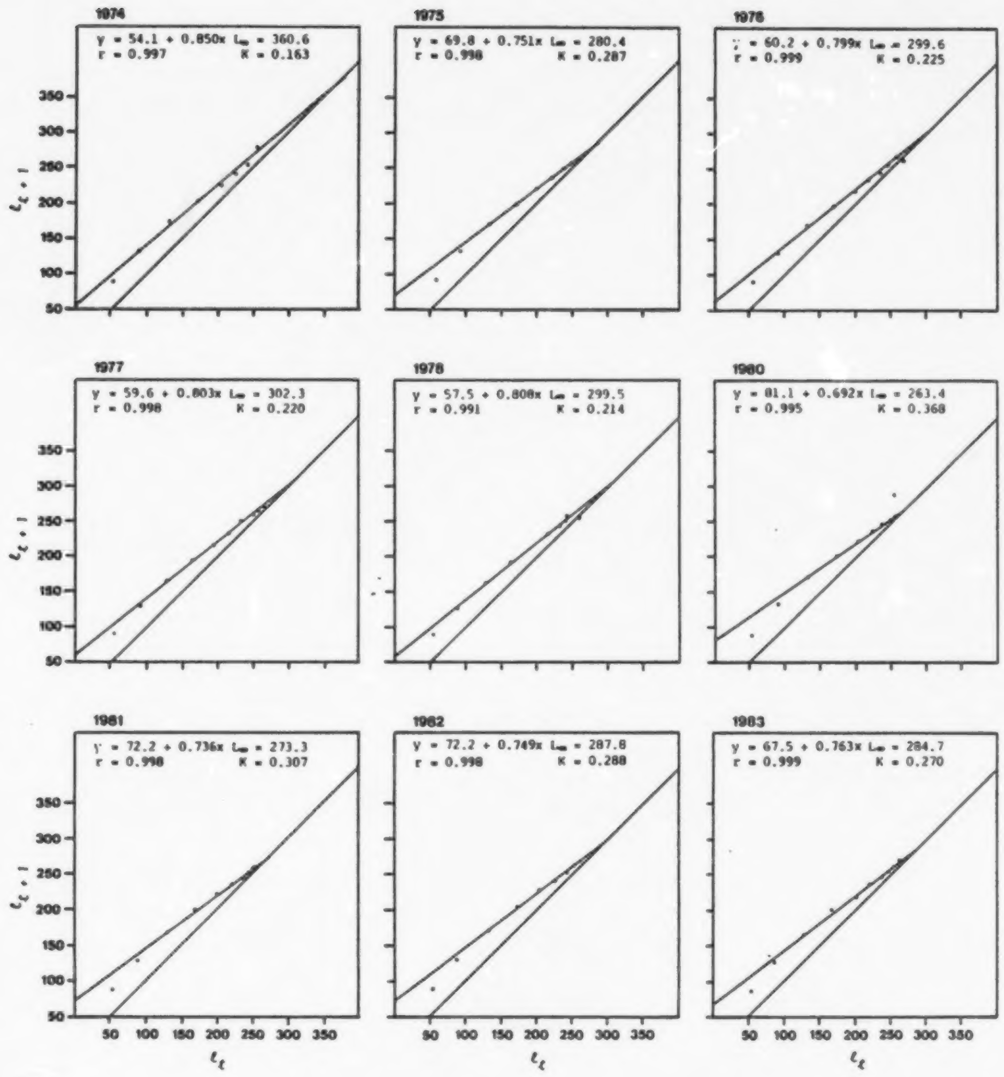


Figure 4.3-2. Walford plots of weighted mean backcalculated fork lengths ($\ell$,mm) at age ($t$+1) against weighted mean backcalculated fork lengths ($\ell$,mm) at age $t$ for combined sexes of rock bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1974-1983).

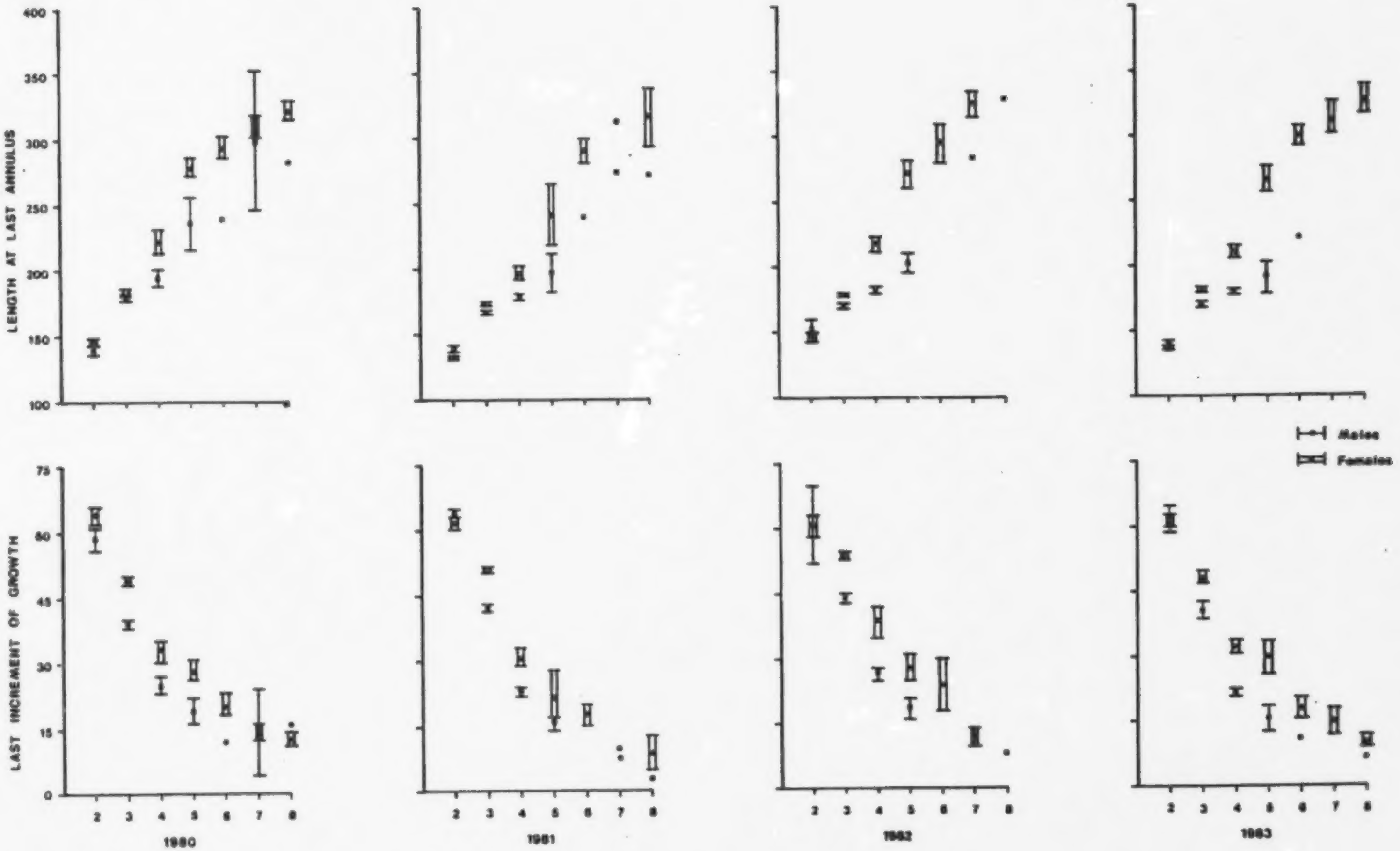


Figure 4.3-3. Mean backcalculated fork length (mm) and growth increments (mm) at age for male vs. female yellow perch taken at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1980-1983). Vertical bars on rectangles represent 95% confidence intervals.

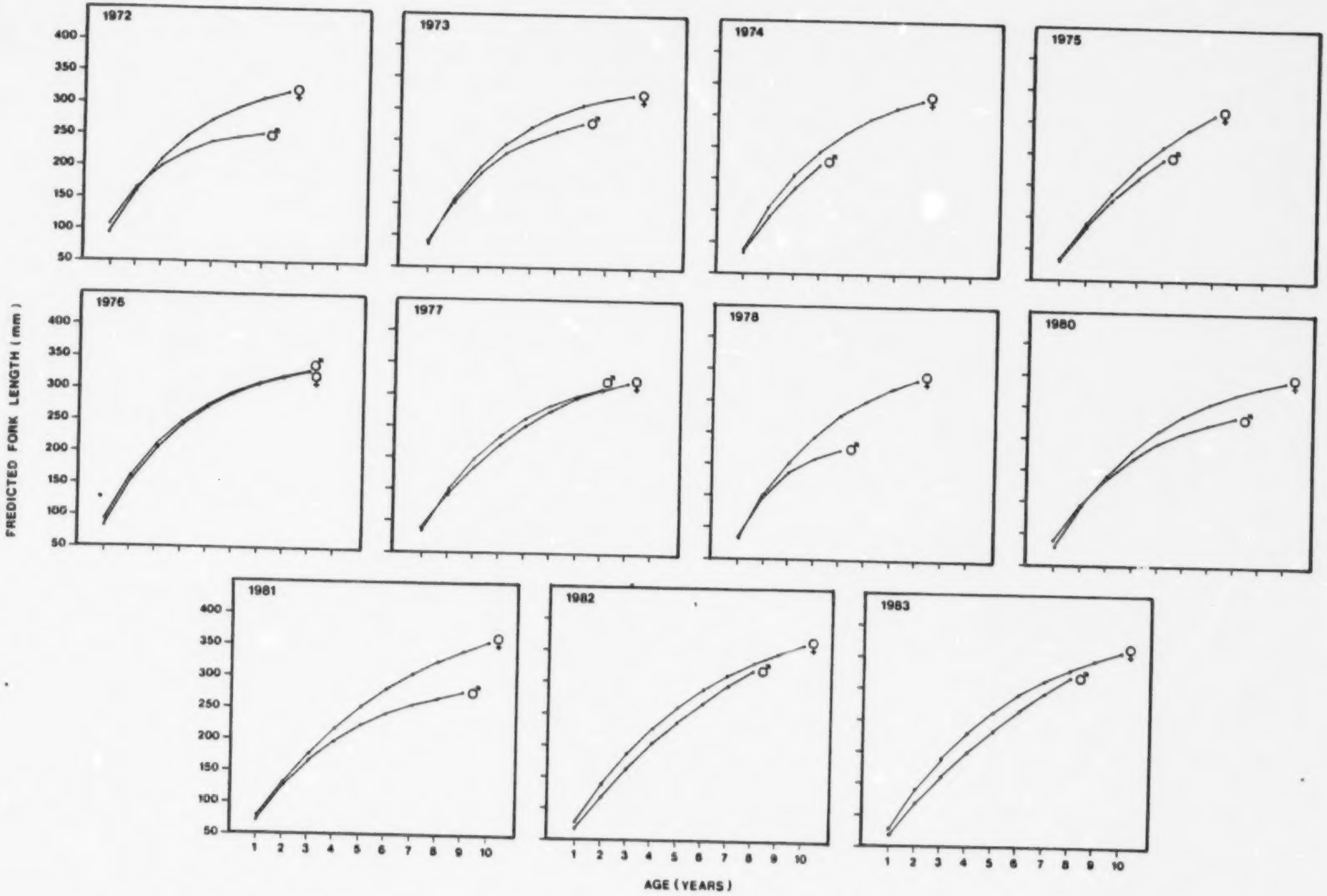


Figure 4.3-4. Von Bertalanffy growth models for male and female perch at Nanticoke, Long Point Bay, Lake Erie, (1971-1983).

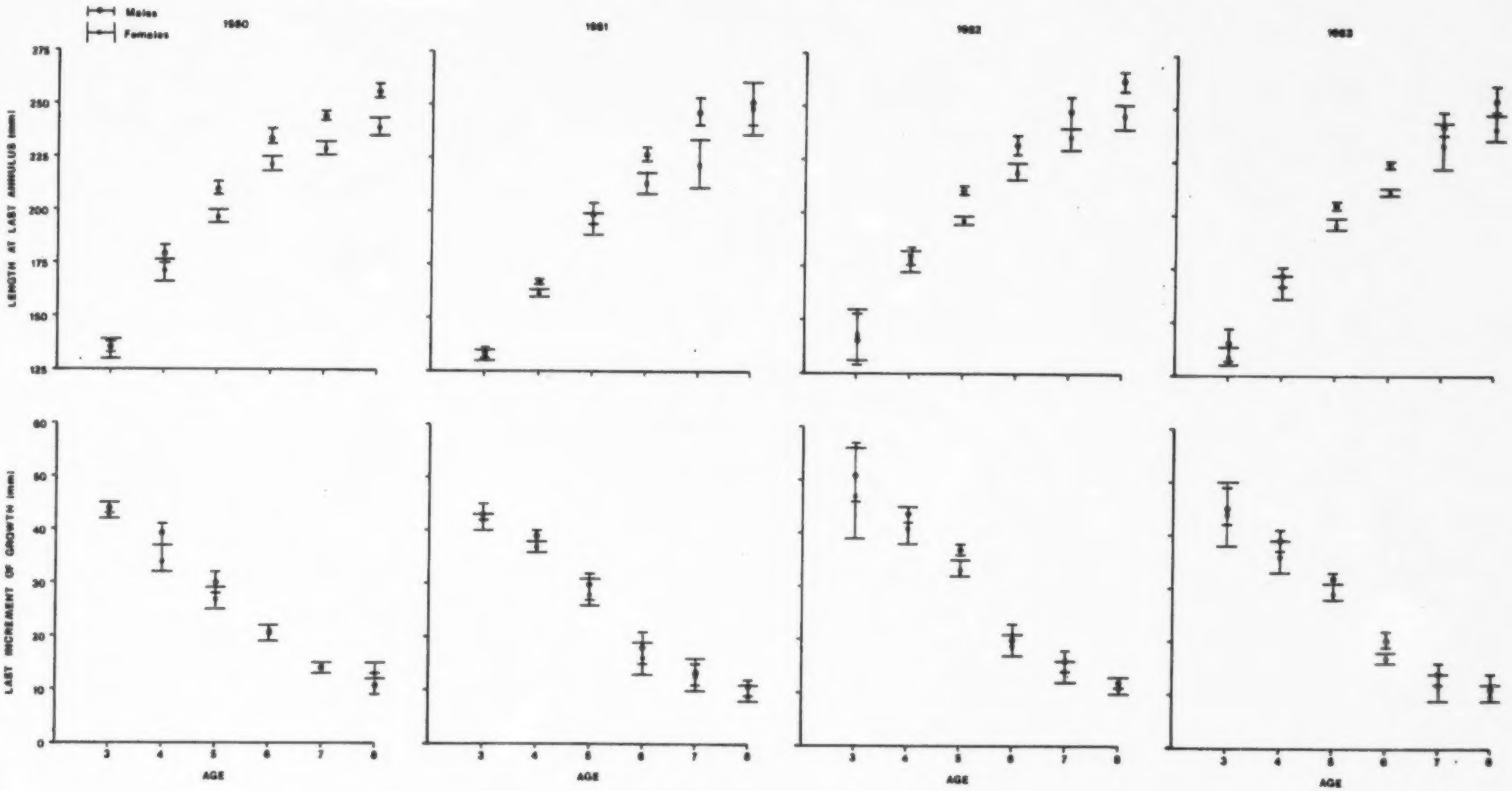


Figure 4.3-5. Mean backcalculated fork lengths (mm) and growth increments (mm) at age for male vs. female rock bass taken at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1980-1983). Vertical bars represent 95% of confidence intervals.

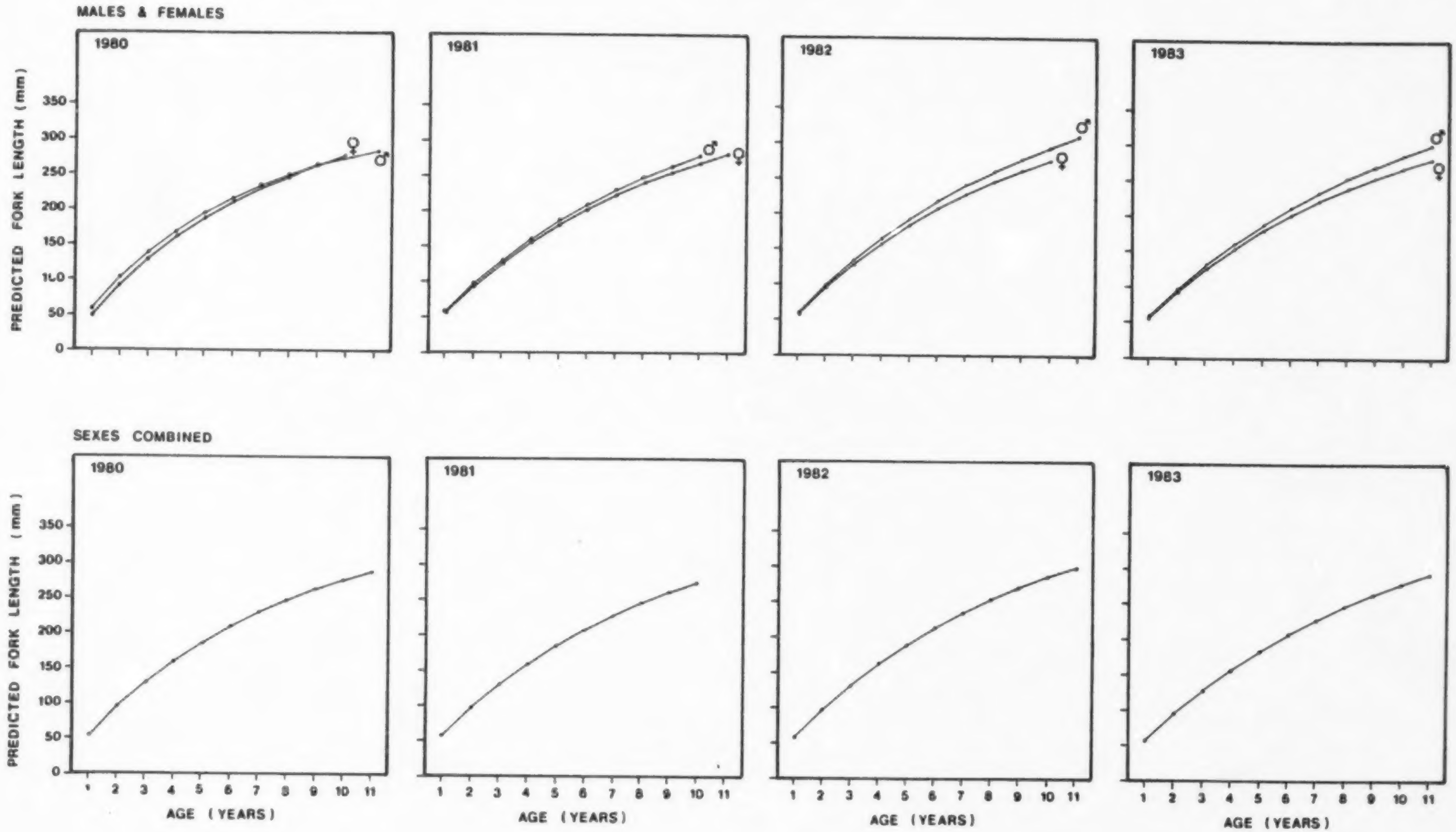


Figure 4.3-6. Von Bertalanffy growth models for rock bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1980-1983).

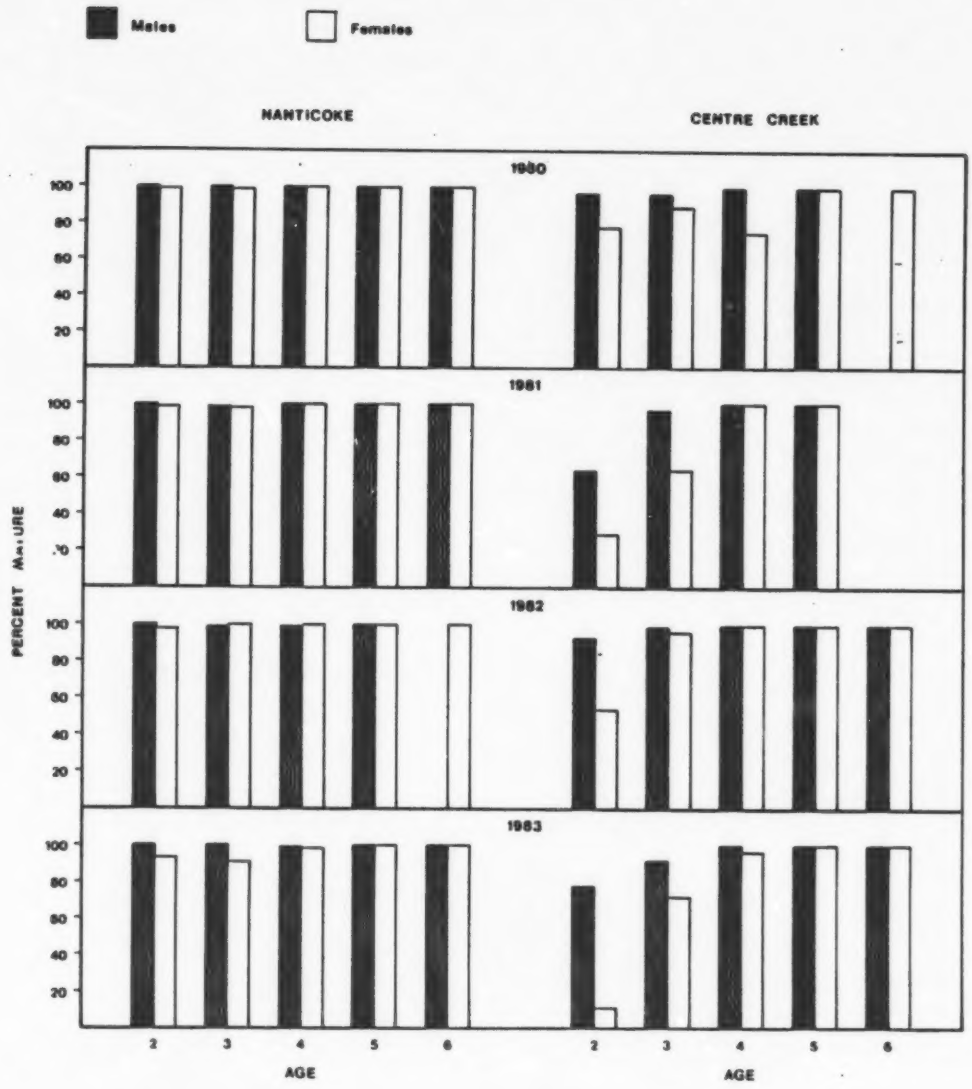


Figure 4.3-7. Percent of male and female yellow perch that were mature at age in Nanticoke (8- and 10-ft.) and Centre Creek (6-ft.) trapnet catches, Long Point Bay, Lake Erie (1980-1983).

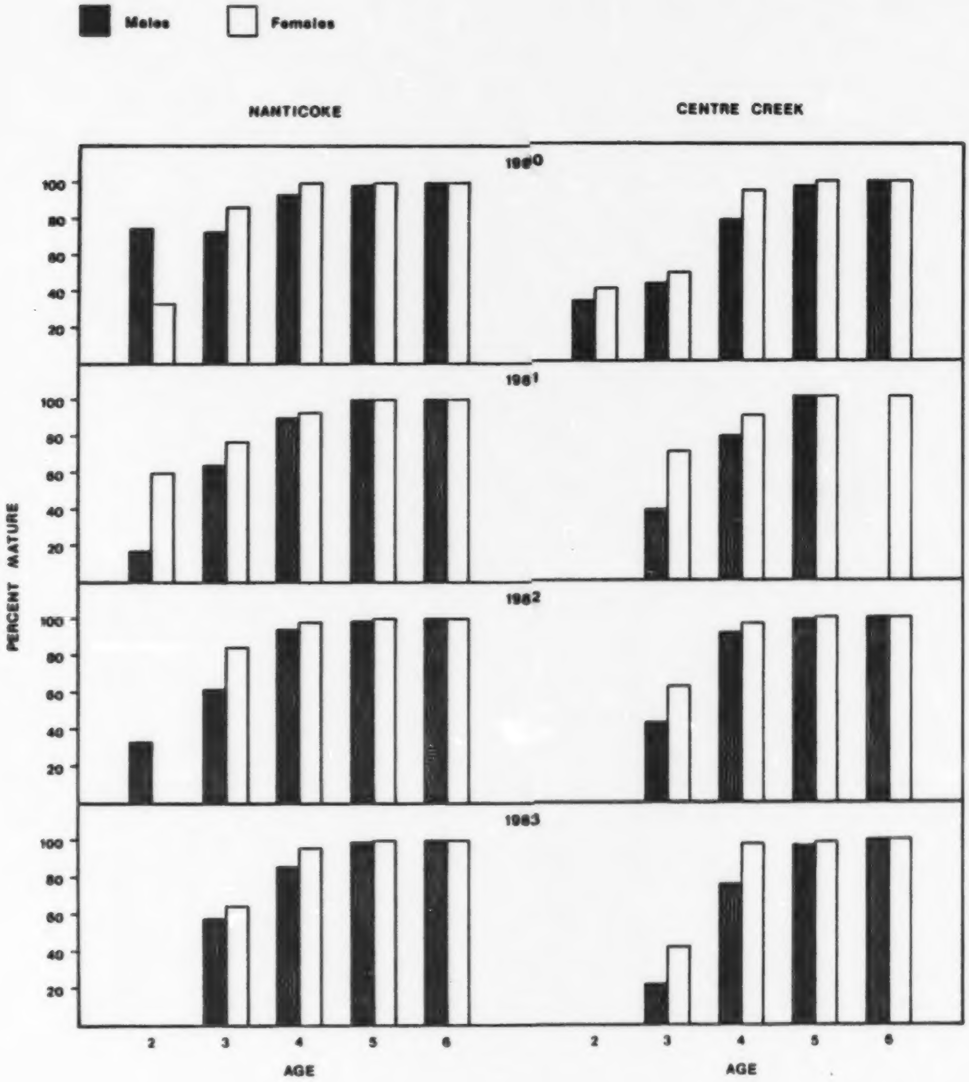


Figure 4.3-8. Percent of male and female rock bass that were mature at age in Nanticoke (8- and 10-ft.) and Centre Creek (6-ft.) trapnet catches, Long Point Bay, Lake Erie (1980-1983).

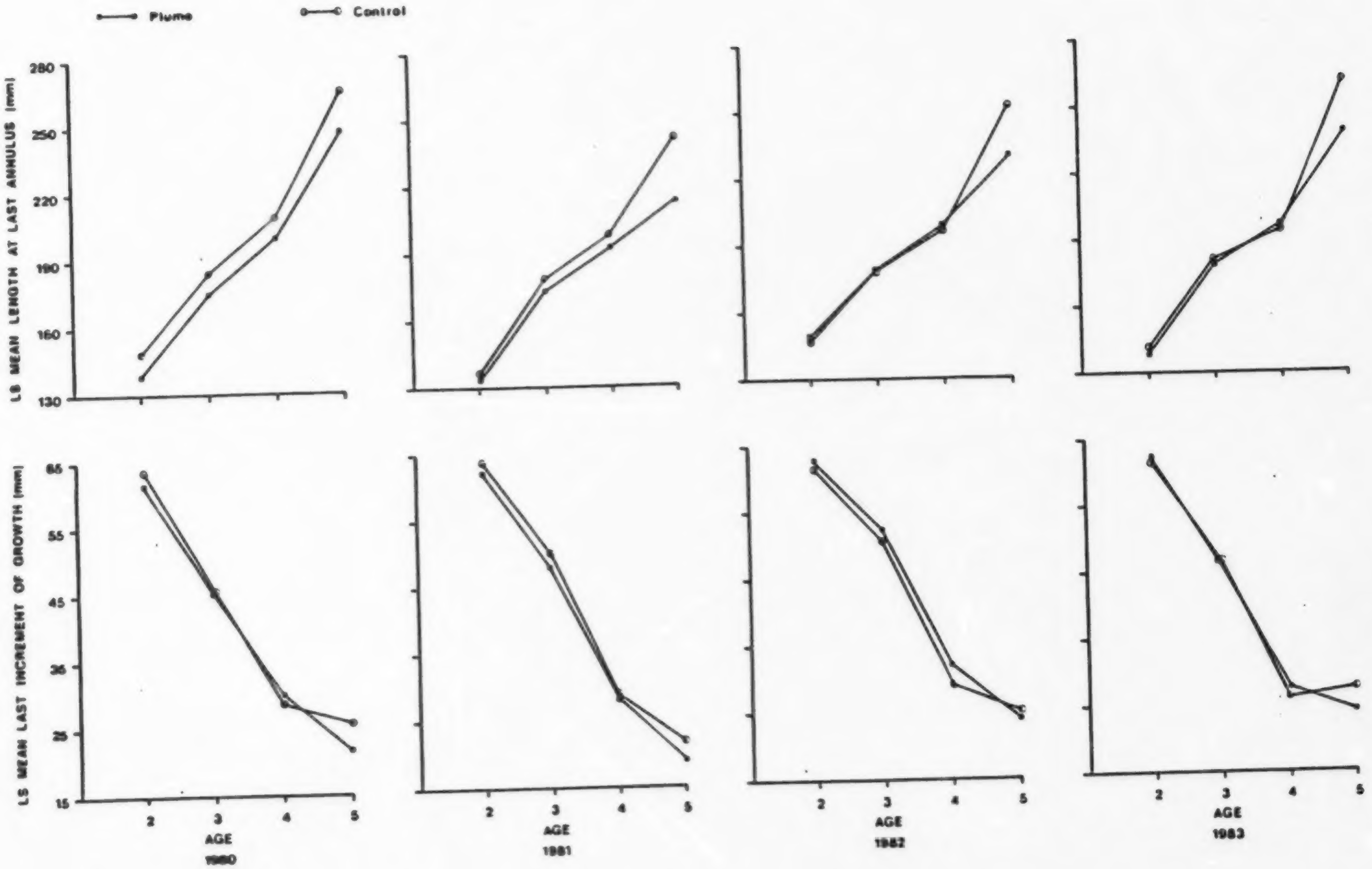


Figure 4.3-9. Age-specific least squares (LS) mean backcalculated fork lengths at last annulus and last increments of growth for yellow perch (sexes combined), captured at plume and control trapnet locations, Long Point Bay, Lake Erie (1980-1983).

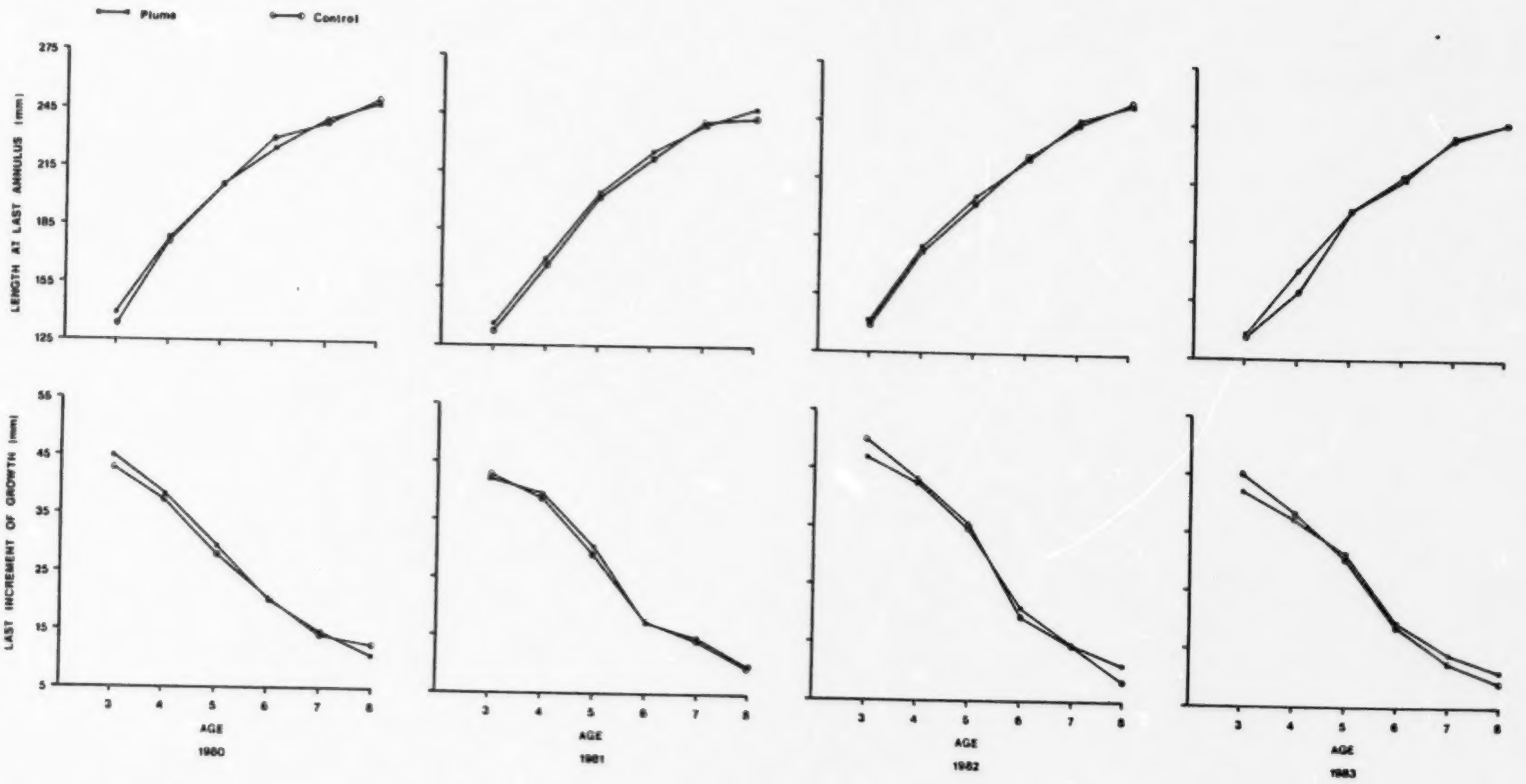


Figure 4.3-10. Age-specific least squares (*LS*) mean backcalculated fork lengths at last annulus and last increments of growth for rock bass (sexes combined) captured at plume and control trapnet locations, Long Point Bay, Lake Erie (1980-1983).

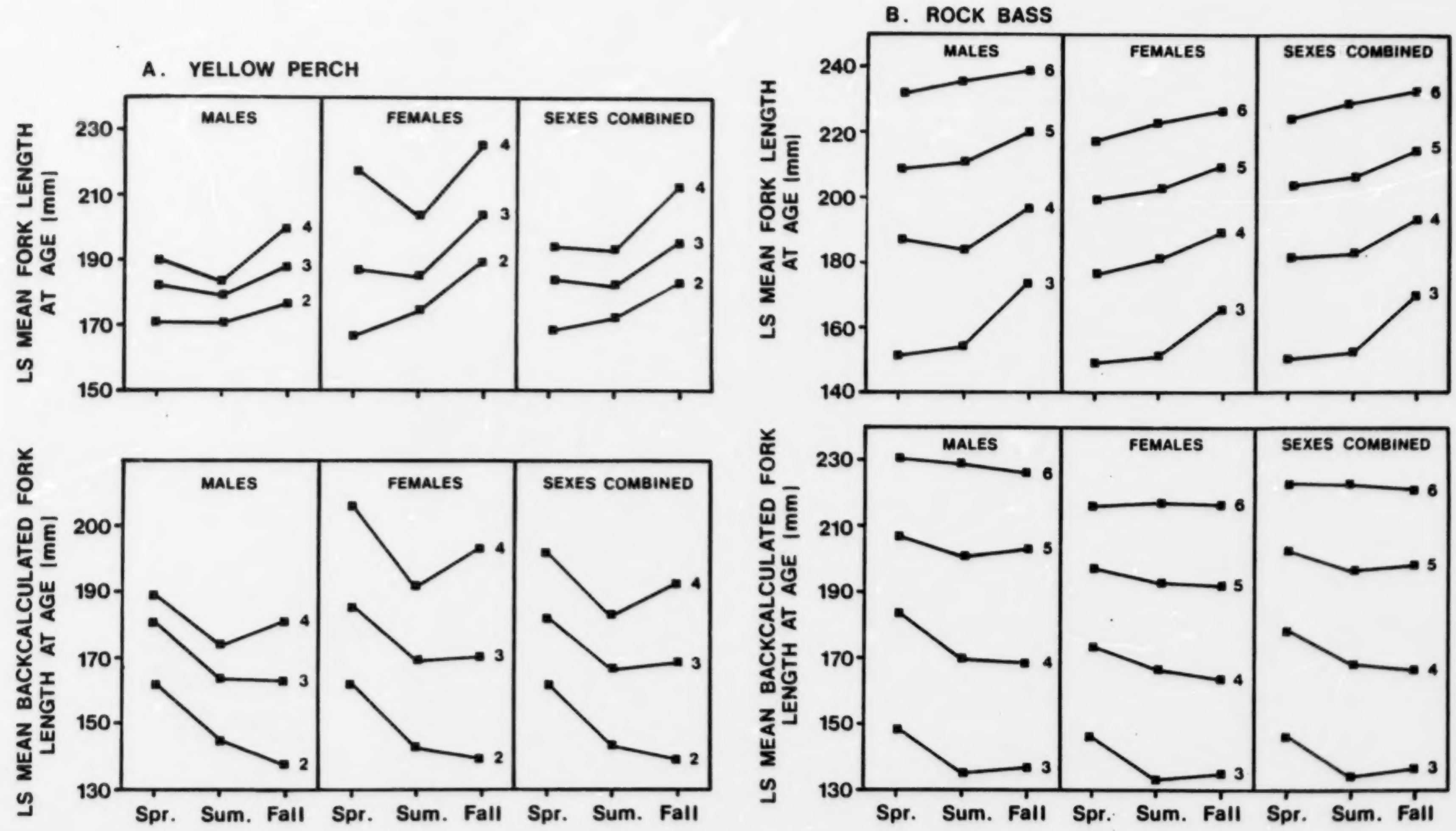


Figure 4.3-11. Seasonal trends in age specific least squares (LS) mean fork lengths at capture (mm), backcalculated fork lengths at last annulus (mm) and last increments of growth (mm) for (A) yellow perch and (B) rock bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1980-1983). Years pooled.

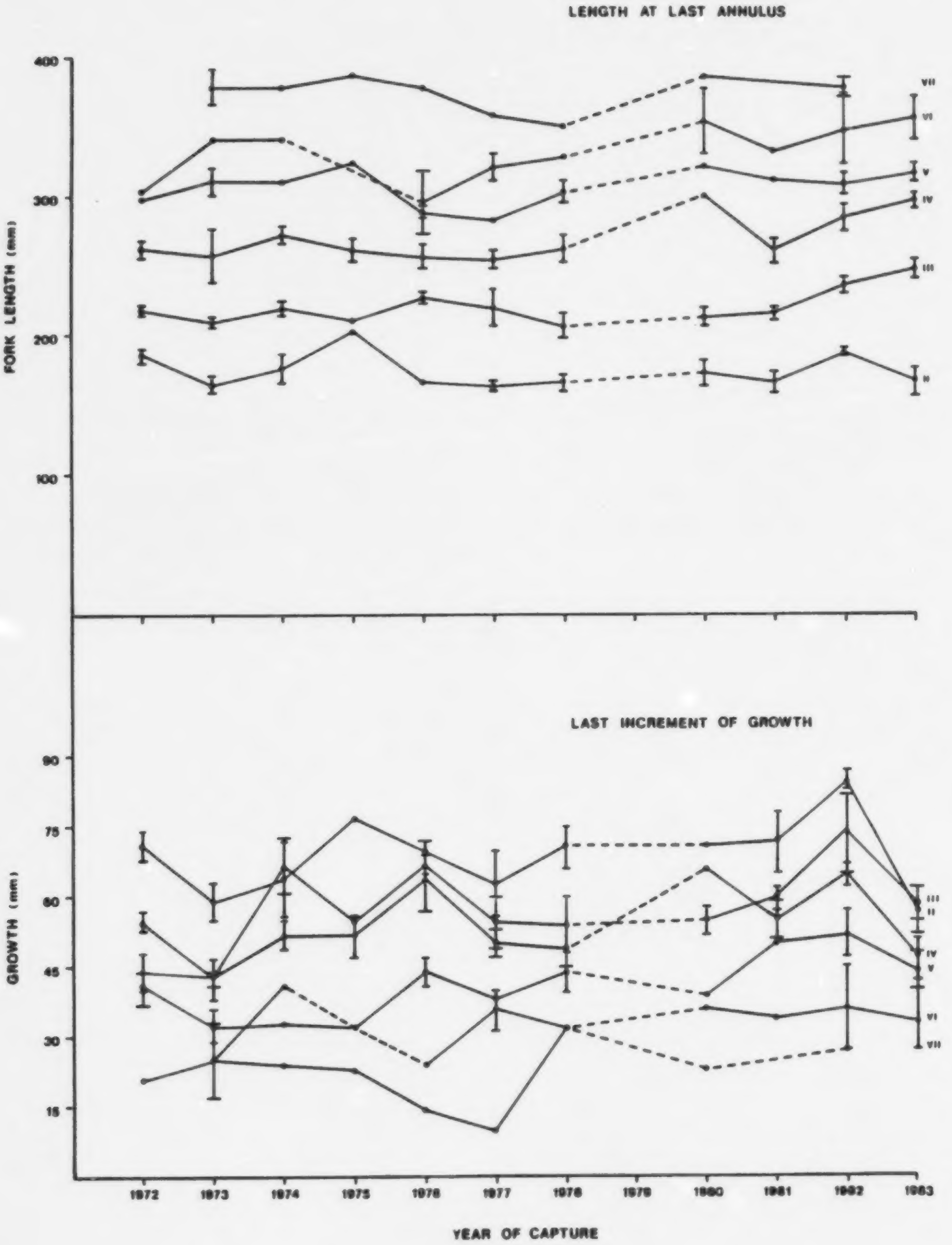


Figure 4.3-12. Fork length at last annulus (mm) and last increment of growth (mm) of smallmouth bass caught at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1972-1983). Vertical bars represent 95% confidence intervals.

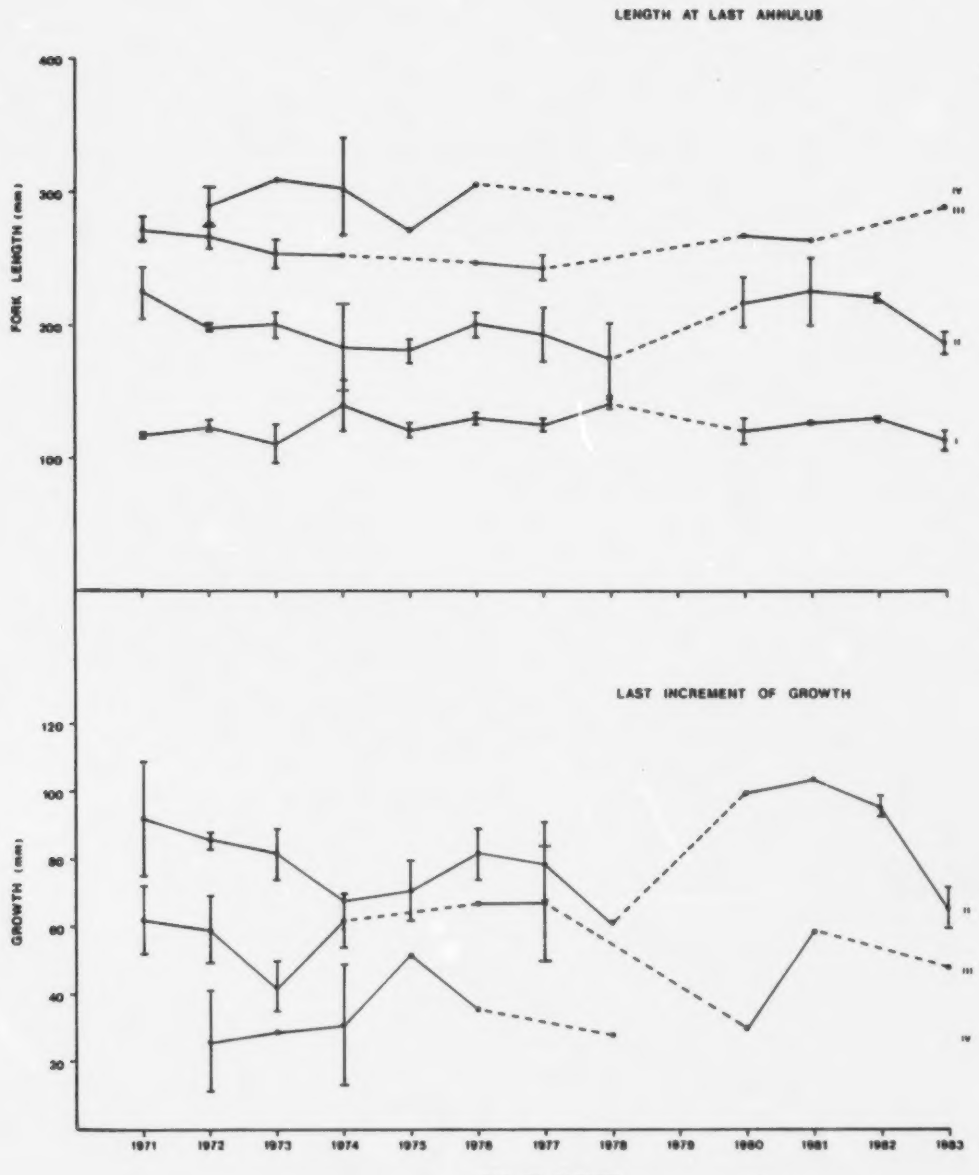


Figure 4.3-13. Fork length at last annulus (mm) and last increment of growth (mm) of white bass caught at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1971-1983). Vertical bars represent 95% confidence intervals.

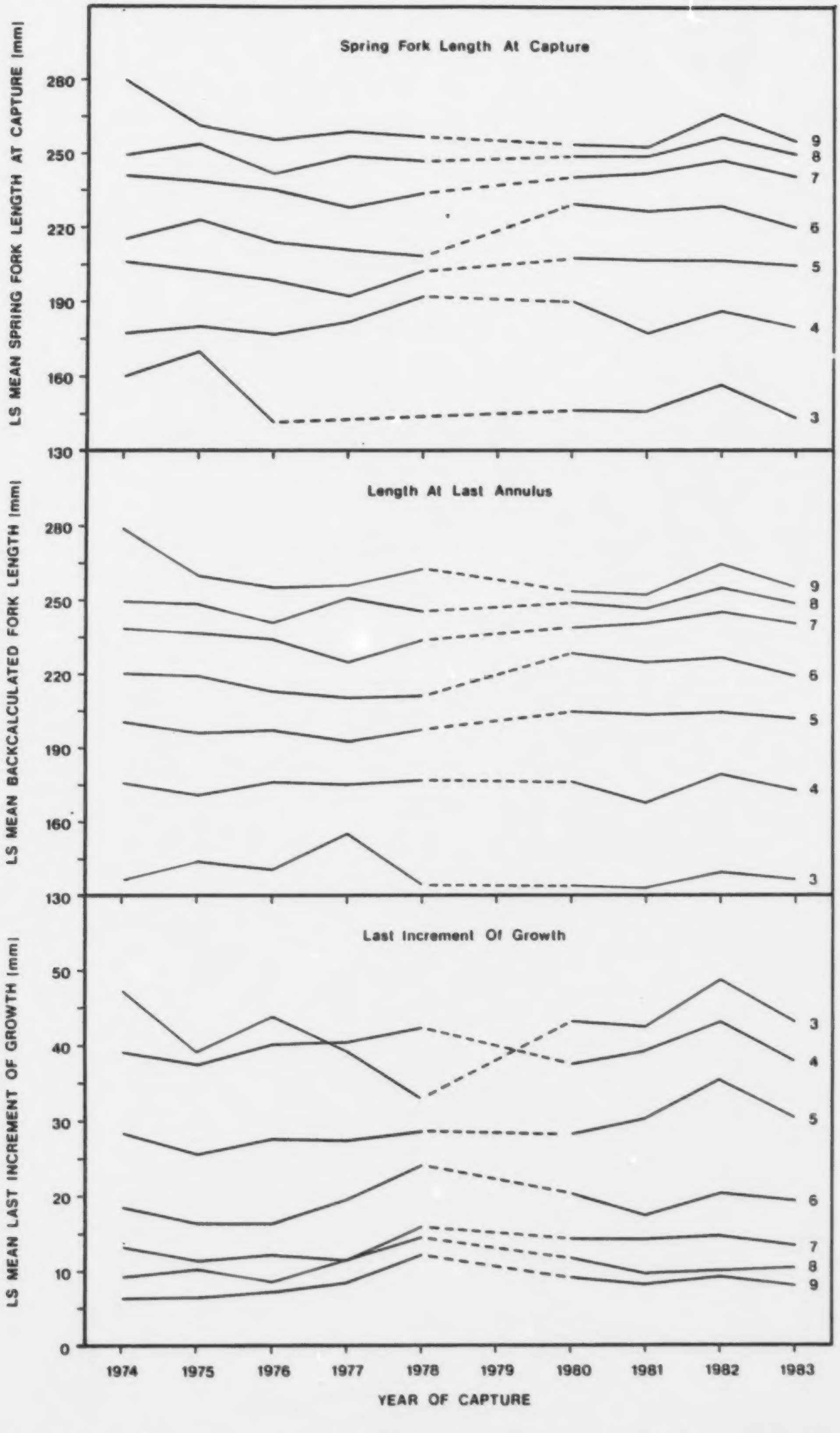


Figure 4.3-14. Trends in Least Squares Mean empirical fork lengths (mm), backcalculated fork lengths at last annulus (mm), and last increments of growth (mm) for combined sexes of rock bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1974-1983).

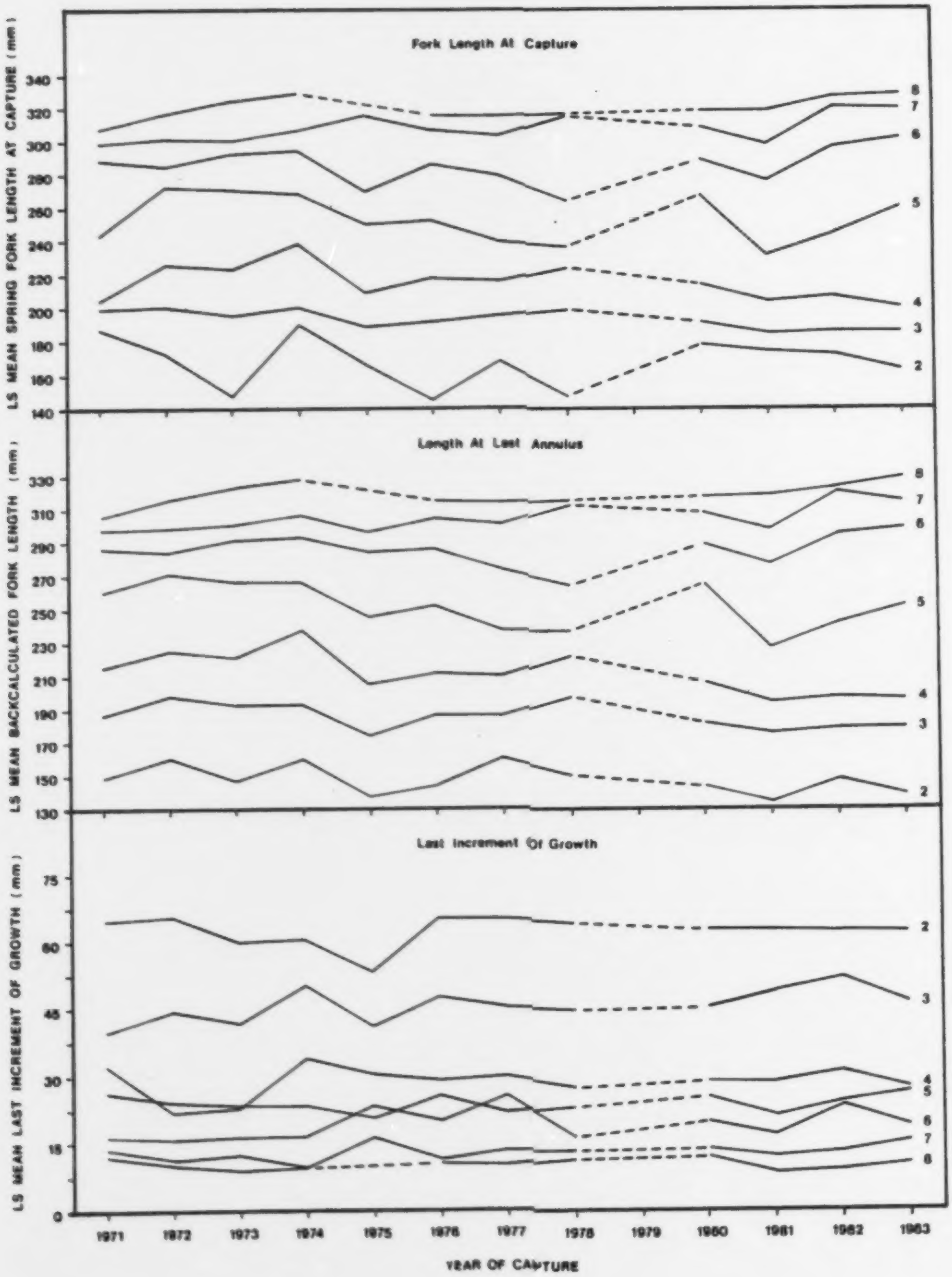


Figure 4.3-15. Trends in Least Squares Mean empirical fork lengths (mm), backcalculated fork lengths at last annulus (mm), and last increments of growth (mm) for combined sexes of yellow perch captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1971-1983).

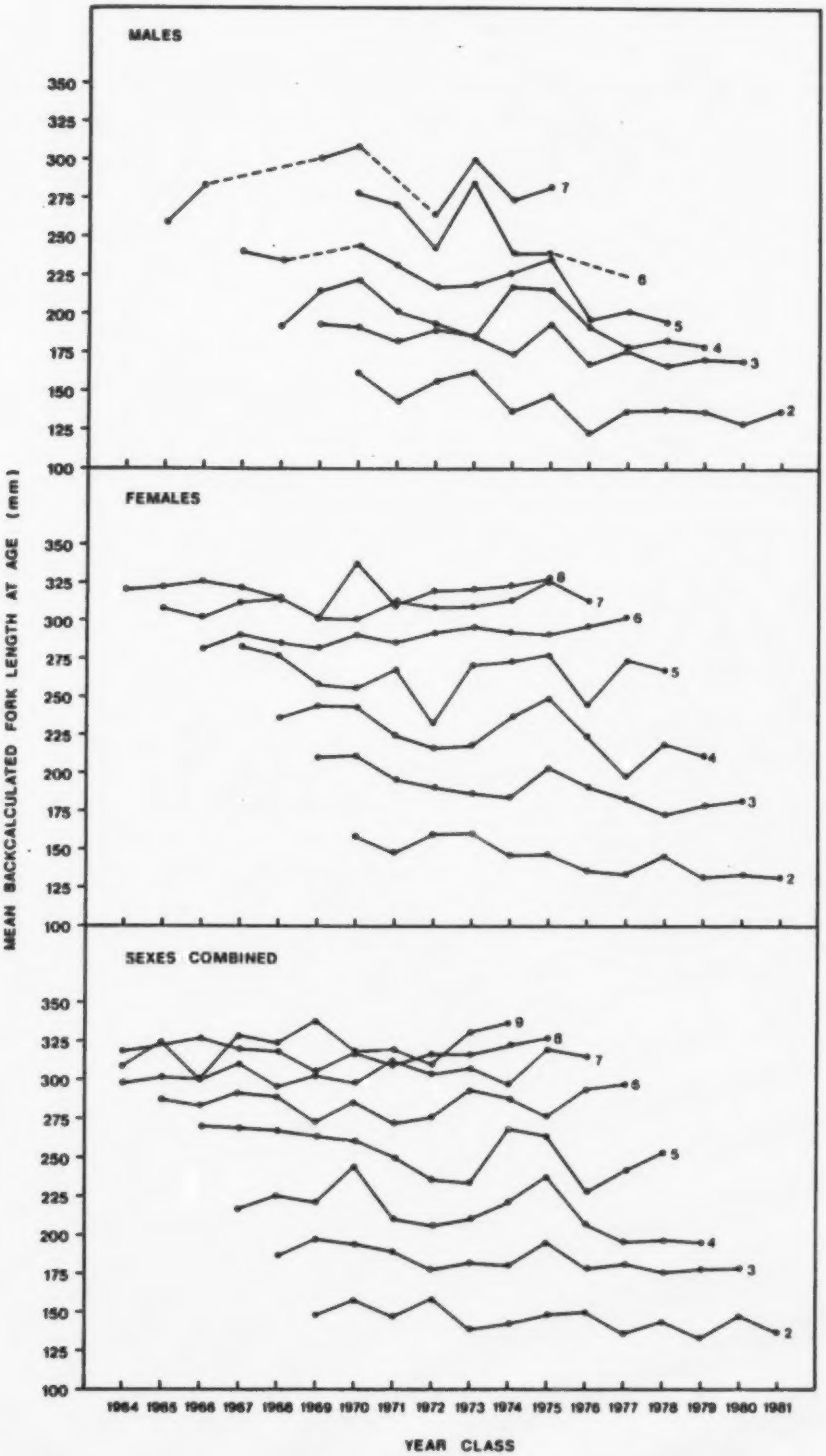


Figure 4.3-16. Trends in mean backcalculated fork lengths (mm) at age for yellow perch year classes (1964-1981) captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1971-1983). Locations pooled.

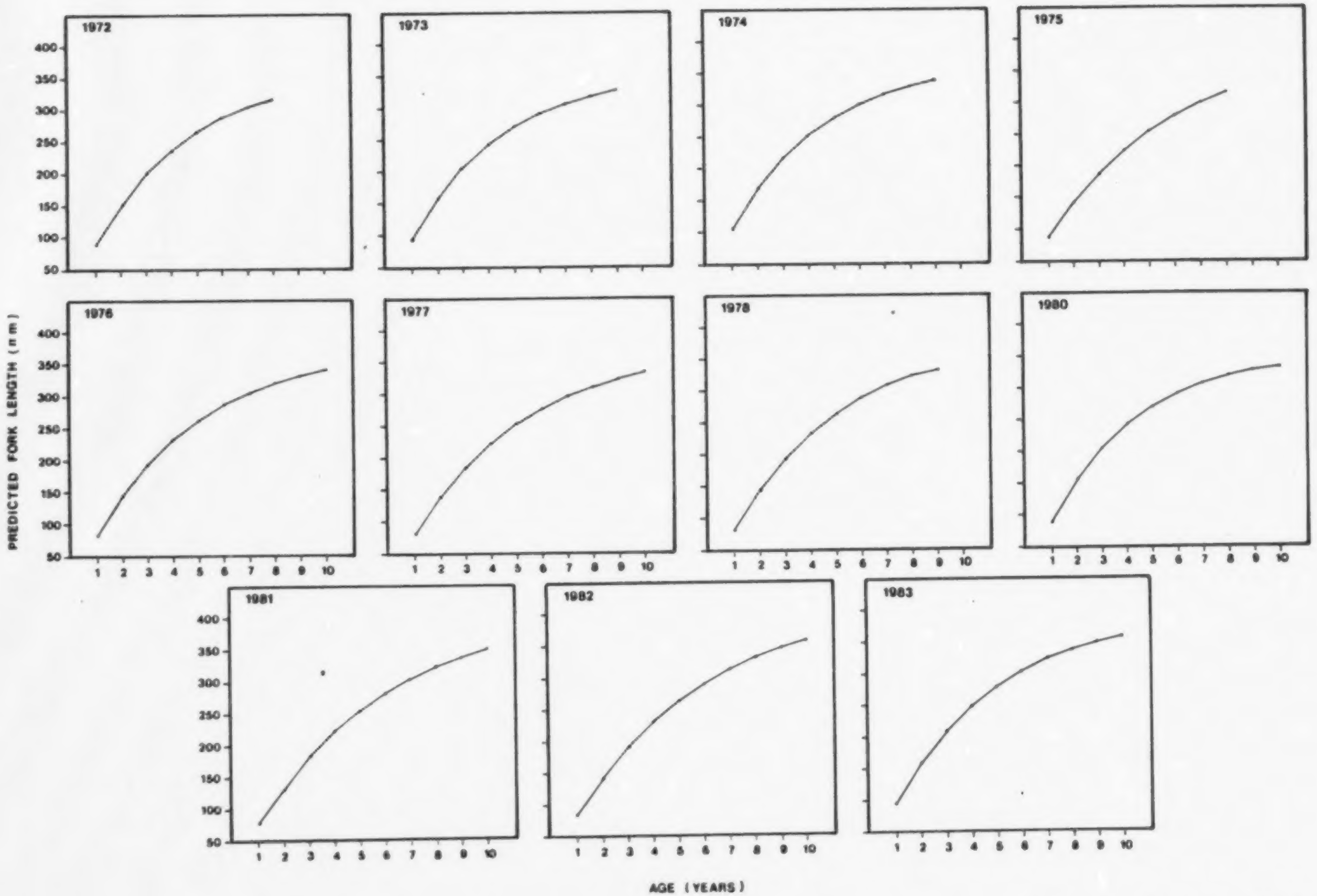


Figure 4.3-17. Von Bertalanffy growth models for combined sexes of yellow perch captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1971-1983).

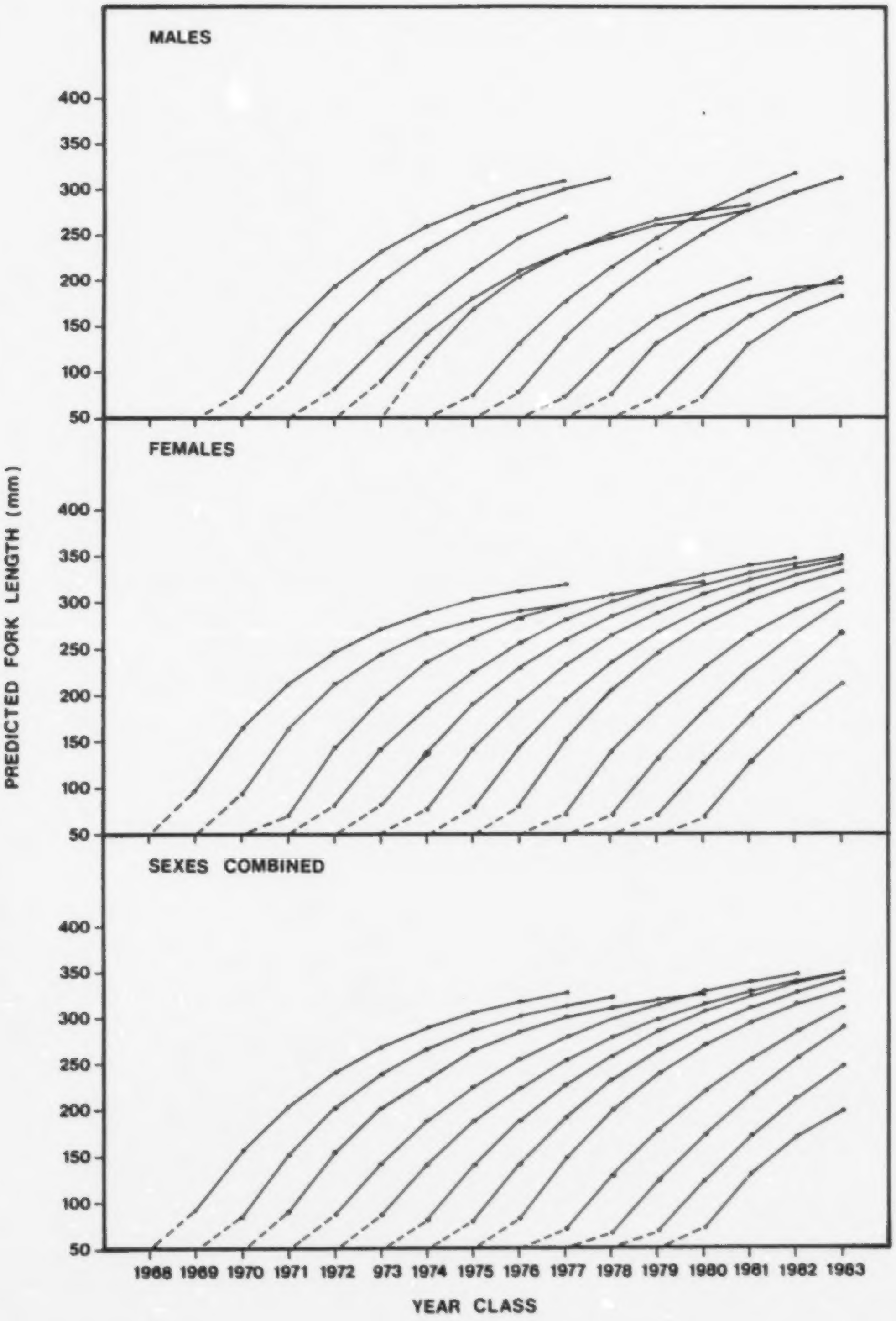


Figure 4.3-18. Von Bertalanffy growth models for the 1968-1971 year classes of yellow perch at Nanticoke, Long Point Bay. Lake Erie (1971-1983).

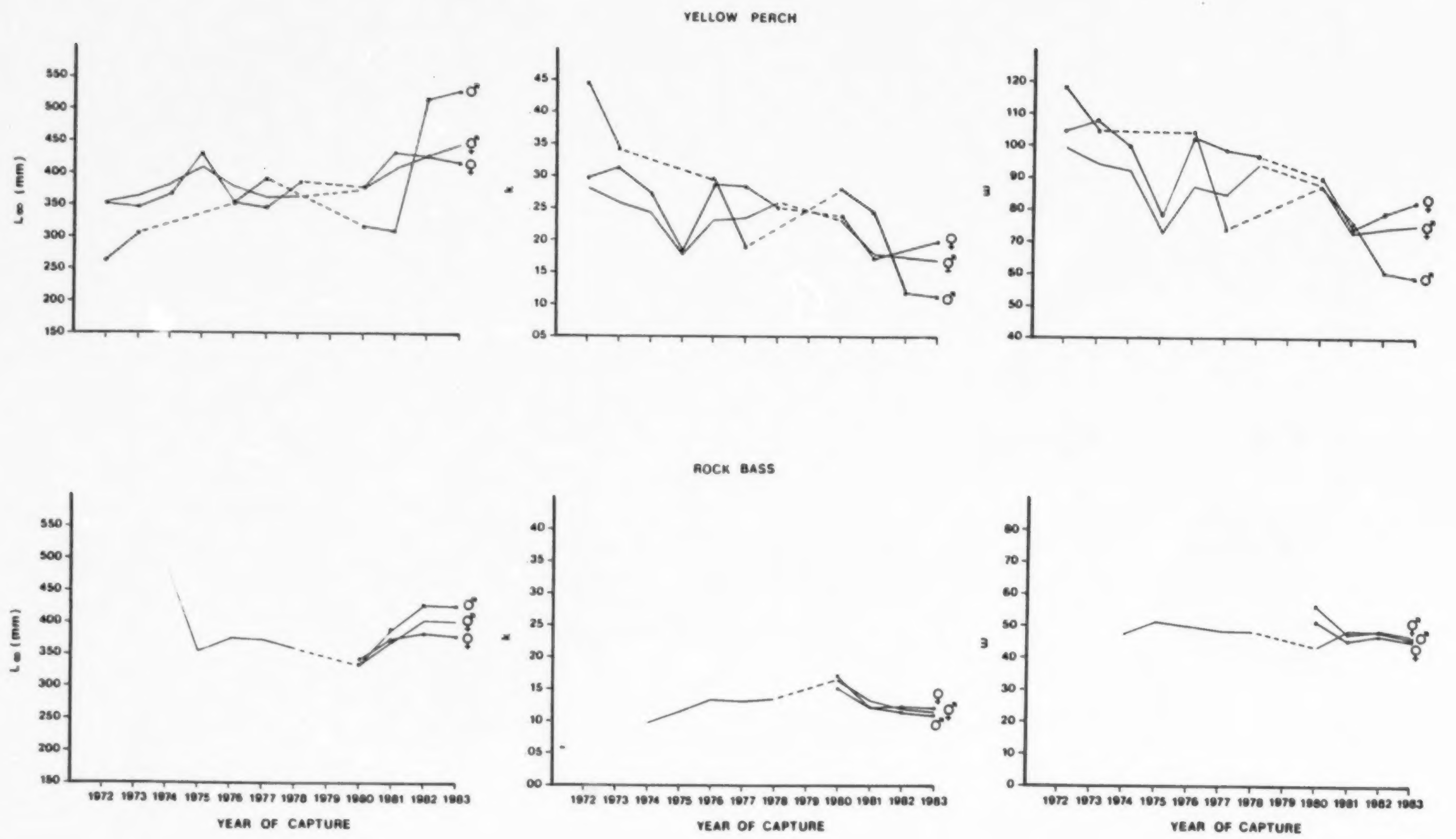


Figure 4.3-19. Trends in von Bertalanffy growth parameters (L∞, K and ω) for yellow perch and rock bass captured at Nanticoke, Long Point Bay, Lake Erie (1972-1983).

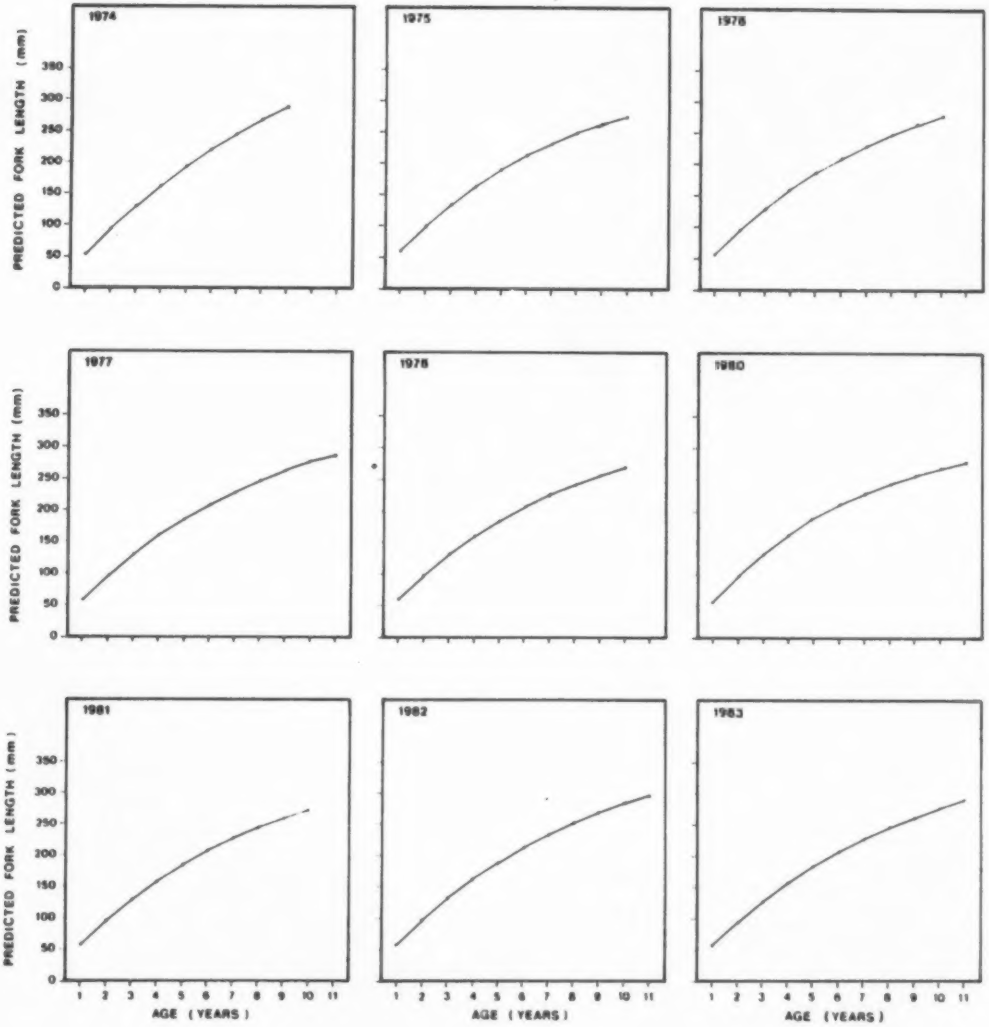


Figure 4.3-20. Von Bertalanffy growth models for combined sexes of rock bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1974-1983).

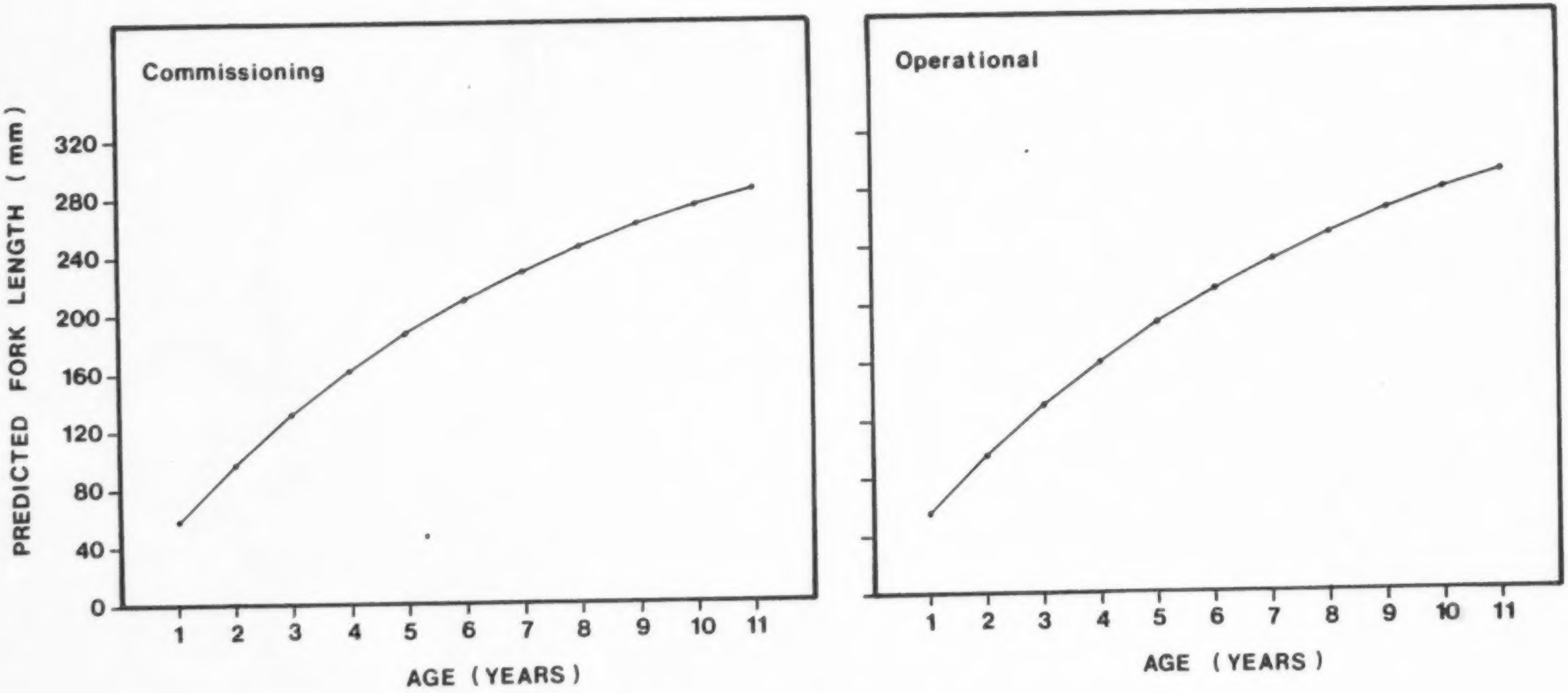


Figure 4.3-21. Von Bertalanffy growth models for combined sexes of rock bass captured in the commissioning and operational periods at Nanticoke, Long Point Bay, Lake Erie (1974-1983).

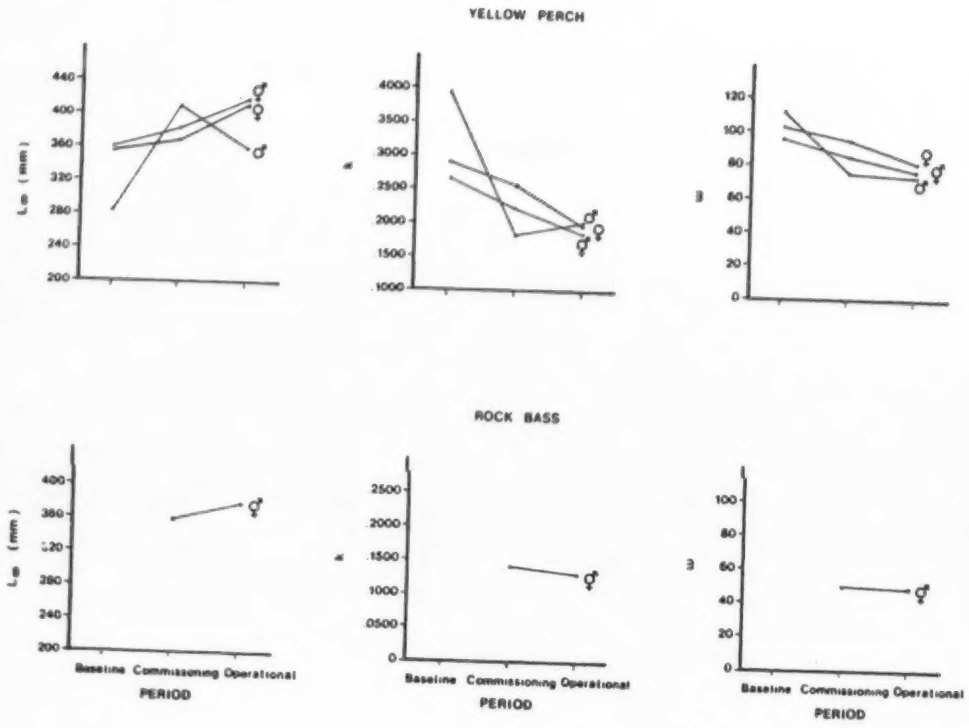


Figure 4.3-22. Trends in von Bertalanffy growth parameters for yellow perch and rock bass across the periods of industrialization at Nanticoke, Long Point Bay, Lake Erie (1971-1983).

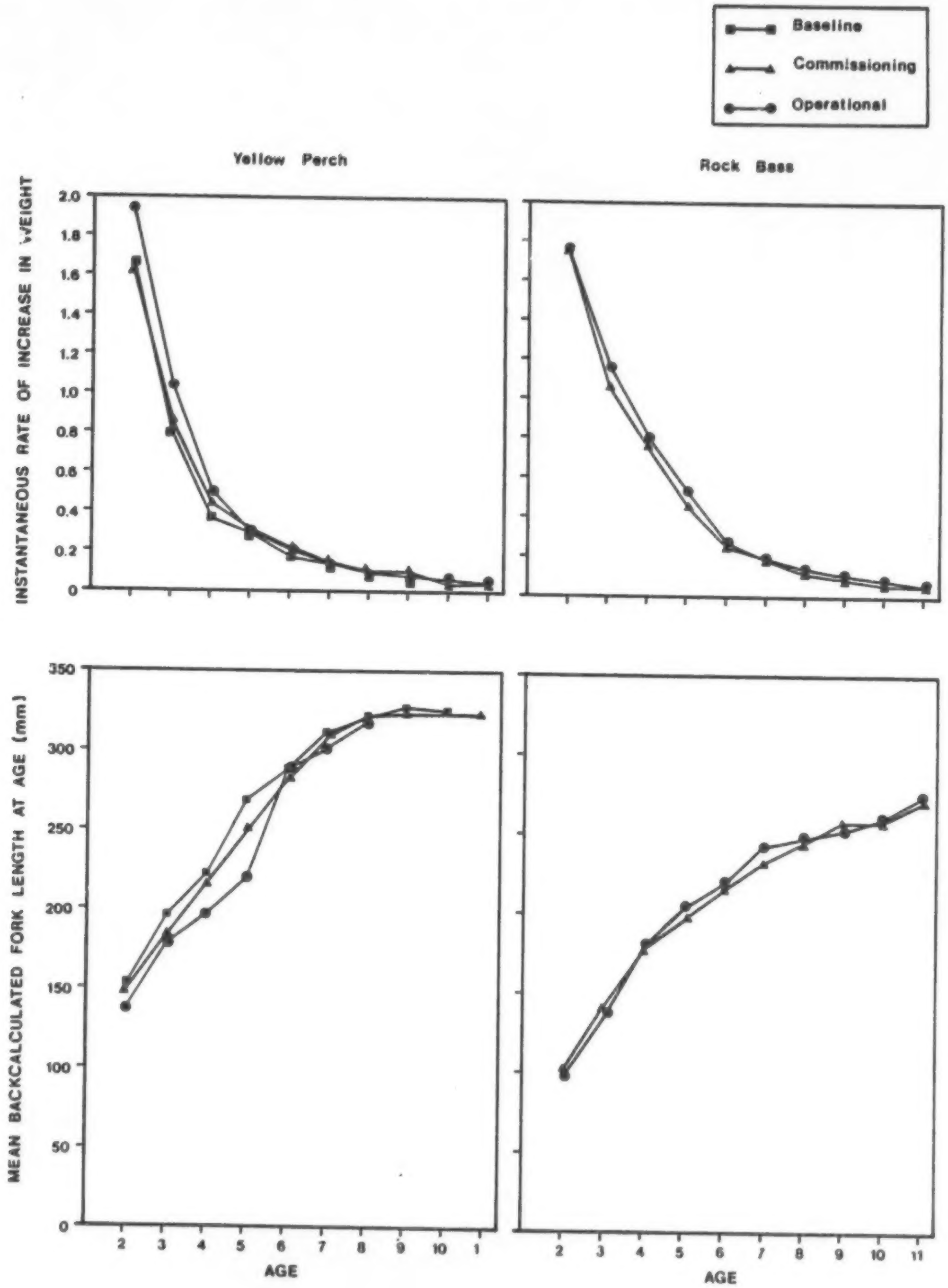
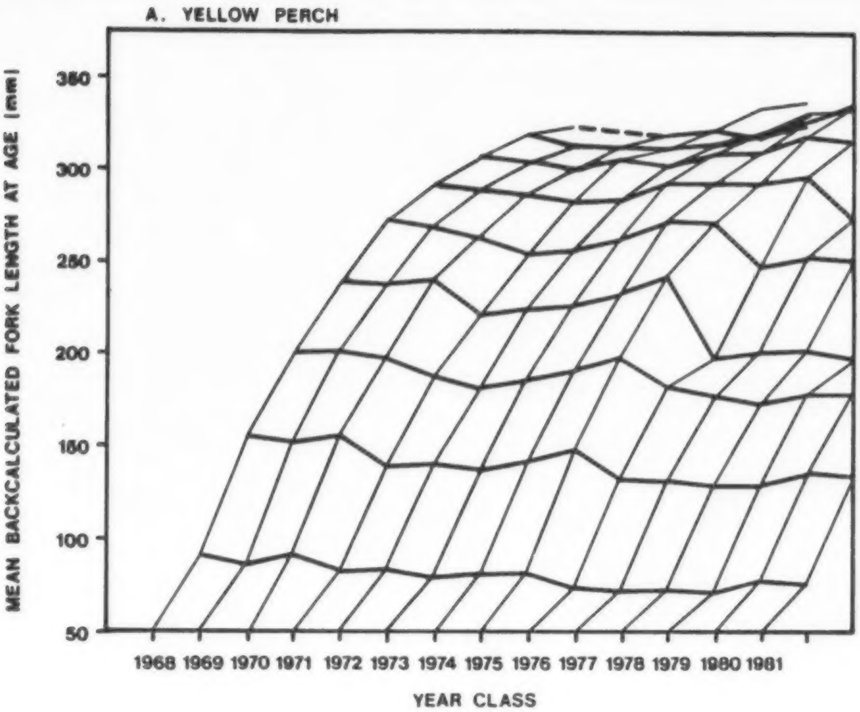


Figure 4.3-23. Instantaneous rates of increase in weight and backcalculated fork lengths at age (mm) for yellow perch and rock bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie, during the baseline, commissioning and operational periods. Locations and sexes combined.



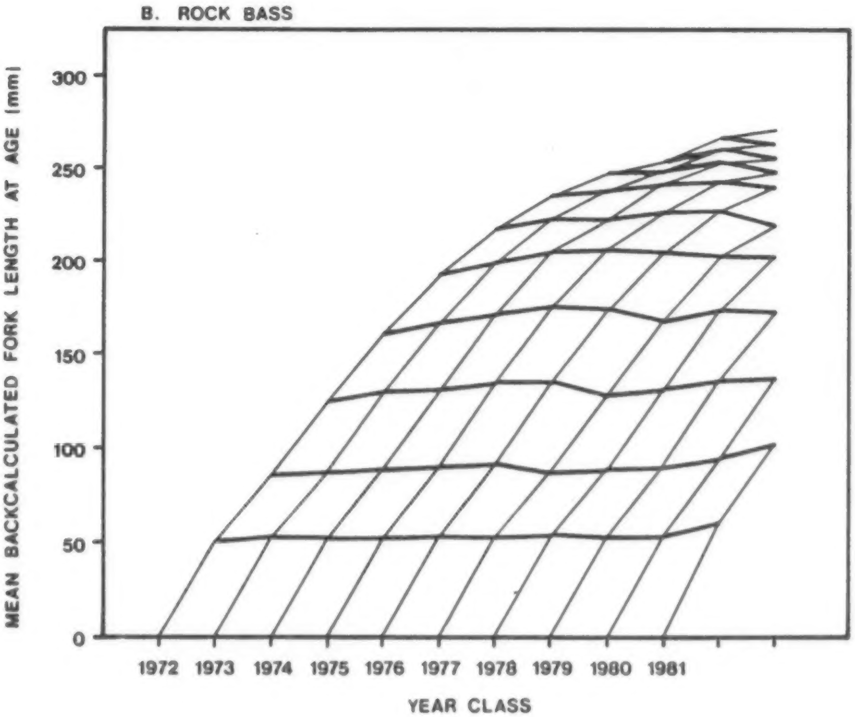


Figure 4.3-24. Weighted mean backcalculated fork lengths of (A) yellow perch and (B) rock bass at age captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1971-1983). Summarized by year class for combined sexes.

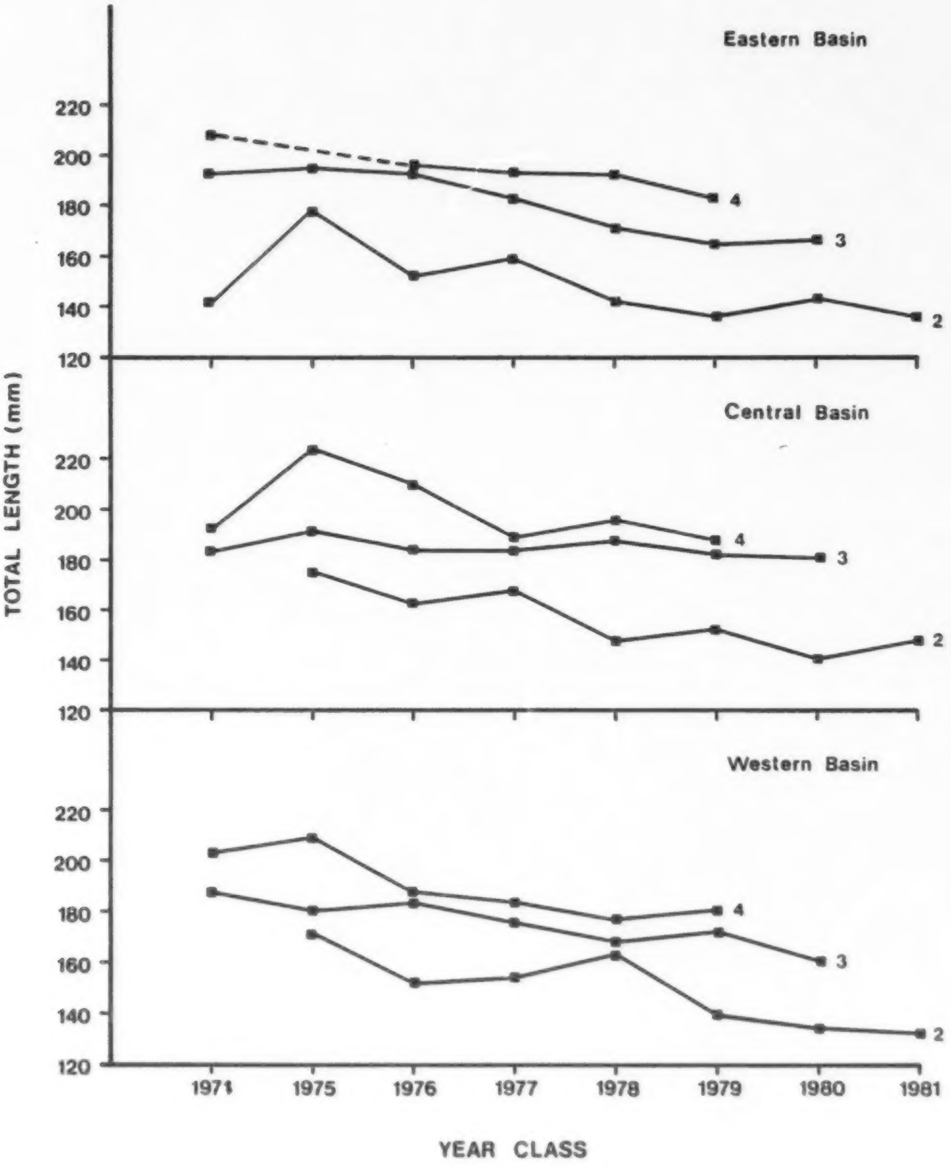


Figure 4.3-25. Trends in spring empirical total lengths (mm) of yellow perch captured by experimental index gillnets fished at standard locations in the Eastern, Central and Western Basins of Lake Erie (1976-1983) (OMNR unpublished data).

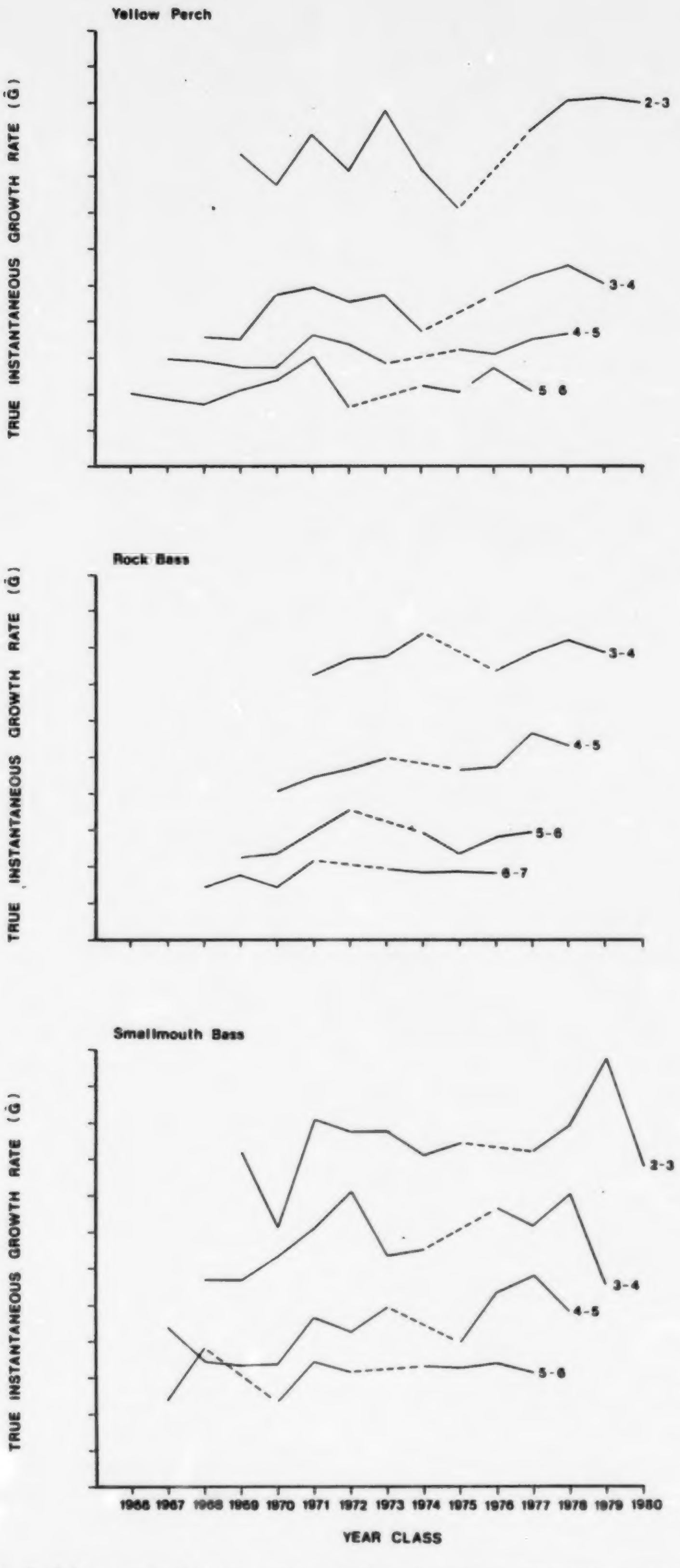


Figure 4.3-26. Trends in true instantaneous growth rates ($\overline{G}$) across year classes of yellow perch, rock bass and smallmouth bass captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1971-1983).

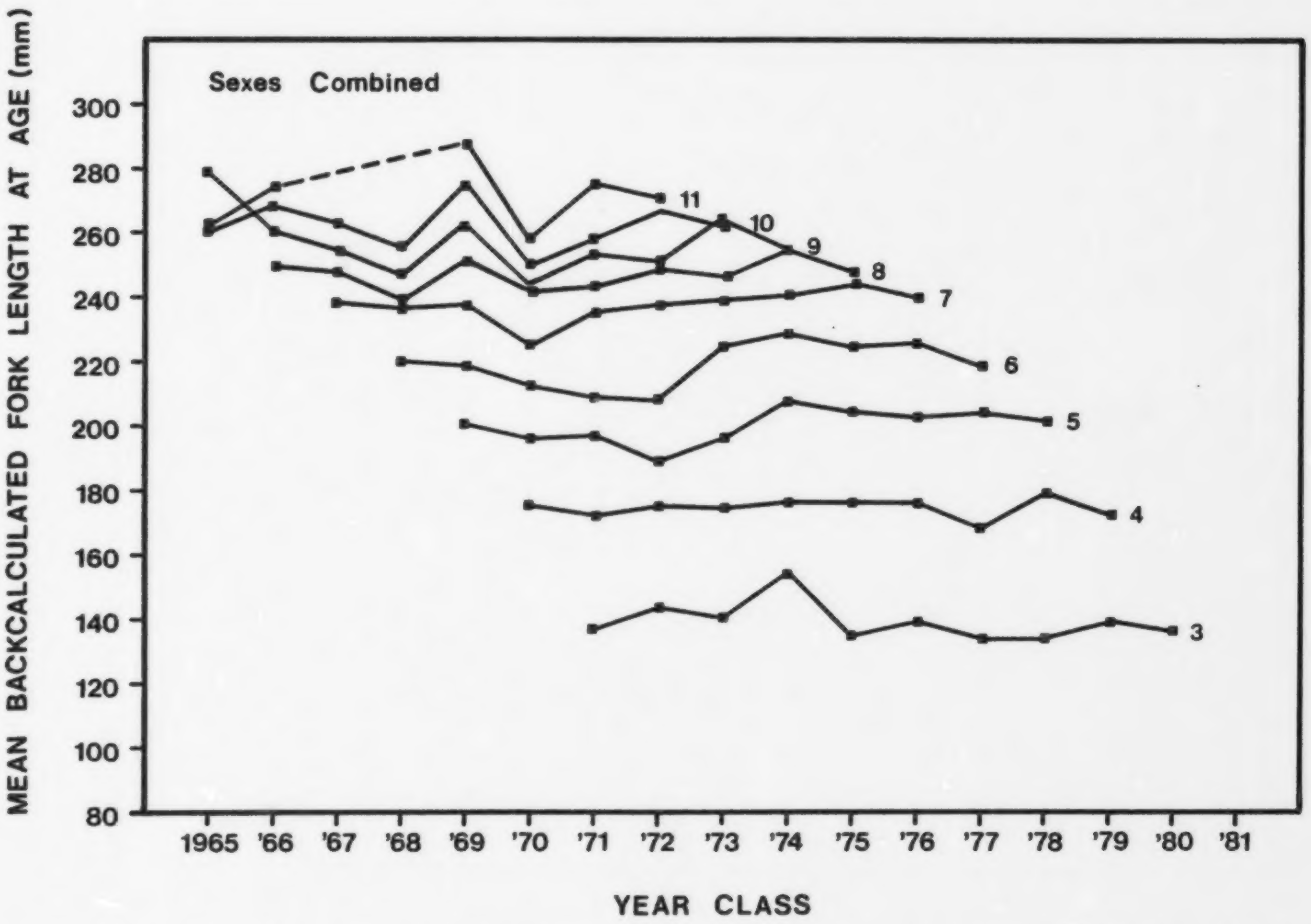


Figure 4.3-27. Trends in mean backcalculated fork lengths (mm) of rock bass year classes (1965-1981) at last annulus captured at Nanticoke trapnet locations, Long Point Bay, Lake Erie (1974-1983).

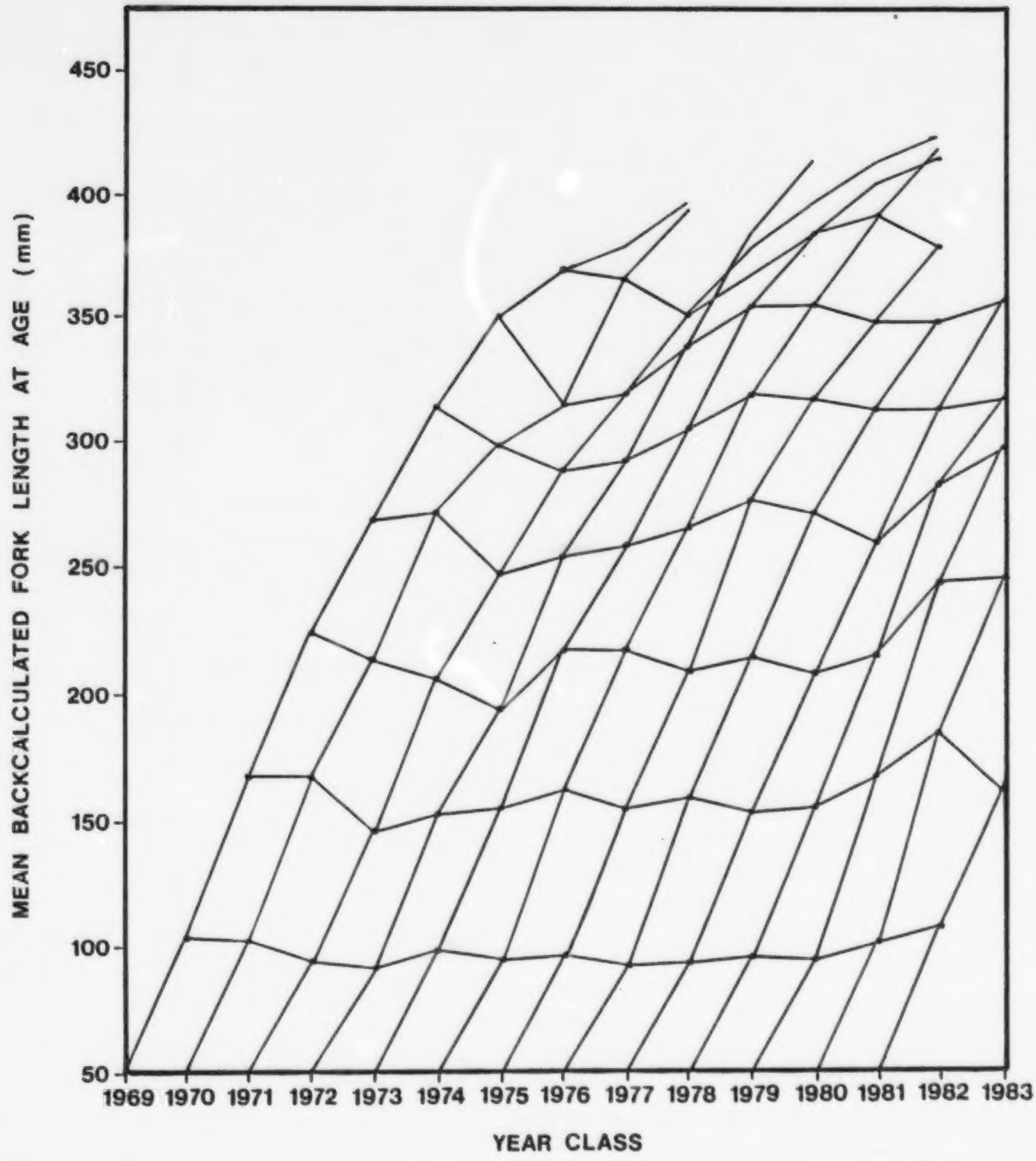


Figure 4.3-28. Weighted mean backcalculated fork lengths (mm) of smallmouth bass year classes (1969-1981) at age, Nanticoke, Long Point Bay, Lake Erie (1972-1983). Sexes combined.

## 5.0 SUMMARY AND CONCLUSIONS

The major impetus for this project has been industrialization and its potential for inducing changes in the fish community of Long Point Bay. This investigation is only one of a series of NEC programs examining the response of a variety of abiotic and biotic components of the aquatic environment to industrialization. The results of this study will be included in a final effects report (in preparation by Ontario Hydro) which will integrate the findings of all NEC aquatic programs. This investigation began at a time when few studies of similar scope had been completed. Consequently, appropriate information regarding the issues of concern was scant during initial design of the program, and few tested methodologies had evolved. Thus, there has been a substantial developmental component in our program as evidenced by several largely methodological publications that have resulted from the project (Kelso 1973a, b, 1976; Hamley _et al_. 1983, MacLean _et al_. 1982).

In most instances where similar long-term programs have been conducted (eg. Merriman and Thorpe 1976, Hesse _et al_. 1982) the overall approach and methodologies have deviated little from those incorporated in our program, and all have suffered from common interpretive difficulties. In such studies it is extremely difficult to establish suitable control stations that are ecologically similar to the affected stations, and ideal experimental designs cannot be instituted. In most cases, populations cannot be subdivided into test (impacted) and control (unaffected) components; therefore, the usual approach to detecting change has been based on comparisons of preoperational versus operational conditions (Shuter _et al_. 1985). As we have noted in our study, the year-to-year variation in many parameters is naturally high; thus, long time series of data and exceedingly large sample sizes are required to detect even major changes (Shuter et al. 1985, Hesse et al. 1982). Moreover, as we have pointed out in the Introduction, even attributing changes that we have detected to specific causes will be circumstantial because true control situations did not exist. Our evaluations of the effects of industry on the Long Point Bay fish community has been particularly difficult for this reason, and to some degree all three other problems noted by Shuter et al. (1985) have hampered our interpretations.

Of considerable concern were the potential confounding effects of the commercial fishery in Long Point Bay on our data relating to several key fish populations, particularly yellow perch. Management practices concerning this fishery have varied across the study period as have techniques, gear and levels of effort expended by commercial fishermen. The effects of this industry on local fish populations has been inconsistent over the study period; therefore, an important component of our interpretive work has involved an attempt to examine commercial fishing practices and how they may have influenced the parameters we monitored. For instance, we have shown that commercial fishing may have substantially affected the size structure of the perch population, and thus, influenced our interpretation of size-at-age data. The extensive information available from commercial fishing statistics has also provided us with important information concerning the yearly status of some species on a lakewide basis. This information was extremely useful in examining the status of the fish community in the Nanticoke study area relative to basin- or lakewide trends in the species.

Few changes in the fish community at Nanticoke have been detected by this investigation that can be attributed to industrial effects. Those changes that have been detected are quite localized in extent. The following is a summary of the major findings:

(1) Rainbow smelt were the most common species of larval fish captured in tows with plankton nets. This species represented 91% of the total catch and was present in 60% of all tows. Yellow perch larvae, the second most abundant species captured, were present in fewer than 20% of all tows.

(2) Year-to-year differences in indices of larval fish abundance were highly significant, but no relationship with industrial activity was detected. Most of the year-to-year variability was attributed to sampling bias, variability in environmental factors determining survival, and immigration and emmigration patterns during the first few months after egg deposition.

(3) Some 63 different species of adult fish were captured over the study period principally by trap nets and/or gill nets. Yellow perch and rock bass dominated the catches in trap nets (°60%), whereas yellow perch, alewife and gizzard shad dominated the catches in gill nets.

(4) While year-to-year and seasonal variability in indices of adult fish abundance were highly significant, few long-term trends were detected. These fluctuations were considered normal and were shown to reflect basin- or lakewide trends in the relative abundance of fish populations. Much of the seasonal variability in catch was shown to be related to changes in fish behaviour, movement pattterns, and to vulnerability of cohorts to the gear (ie. recruitment of younger age classes into the gear). Day-to-day variations in the catch were due to environmental factors such as temperature and water clarity. Annual fluctuations were attributed to lakewide variations in year-class strengths.

(5) Significant differences in the abundance of adult fish among sampling sites were detected in both trapnet and gillnet catches. These variations were attributed to habitat differences among locations. The most notable trend amongst locations was the consistent tendency (in both gear types)

for fish to be more abundant at or near the warm water outfall of the Nanticoke TGS than at reference sites. Possible reasons for the attraction of fish to this area were discussed.

(6) Fluctuations in harvest and catch success rates of anglers in the summer boat and winter ice fisheries were examined. While some trends were detected, no relationships between these fluctuations and industrial discharge were found. Rather, most of the variations were thought to be due to natural fluctuations in year-class strengths, to total fishing pressure expended by anglers, and possibly to over-harvest of smallmouth bass.

(7) Sport fishing activities have increased substantially at the Nanticoke TGS in response to the attraction of fish to the heated water discharge. Excellent fishing opportunities for white bass and smallmouth bass within a small area of the outfall resulted in angler crowding and exceptional harvests. Angler catch success (white bass and smallmouth bass) was significantly correlated with discharge temperature, suggesting that fish were distributed at the outfall in response to species-specific temperature preferenda. Maximum angling pressure and highest catches occurred in May and June when white bass invaded the discharge area to spawn.

(8) Increased vulnerability of fish concentrated in the discharge area, combined with increased angler pressure warrants some concern of possible over-harvest of the principal species and increased mortality of smallmouth bass through disturbance of their nesting activities prior to open season. However, faster summer growth of young smallmouth bass in the thermal plume may lead to increased overwinter survival, thereby offsetting some effects of angler-induced mortality.

(9) Rock bass undertake a 35-40 km migration each spring from Nanticoke to spaening areas in Inner Bay. During the non-reproductive period they remain in a localized home area, restricting their movements to 5 m of water or less.

(10) Displaced yellow perch returned to spawning sites in the Long Point-Inner Bay area during the spawning season. During the non-reproductive period, perch spawning in the Long Point-Inner Bay area dispersed throughout Long Point Bay and to some extent into the Central (but not Eastern) Basin. Perch tagged and released late (May) in the spawning season at Nanticoke did not demonstrate a distinct movement towards Inner Bay in the release year, but did during subsequent winters. Presumably, perch moved into Inner Bay during the period of ice cover several weeks or months before onset of spawning.

(11) Industrial discharge at Nanticoke and Stelco's 1200-m dock had no discernable effect on the seasonal movements of fish along the north shore of Long Point bay. While fish were attracted to the NTGS discharge area, there was no evidence that residency time in this area was extended. Ultrasonic tracking studies demonstrated that fish movements in the plume primarily were in response to current, and not temperature, and that fish movements there were more localized with sharper turns and shorter distances between turns.

(12) Yellow perch, rock bass, smallmouth bass and white bass exhibited general dietary tendencies typical of the species in most waters. Seasonal fluctuations in perch diet were due largely to fluctuations in abundance of the prey items. Amphipods were the dominant food items consumed by perch over the entire study period. Yellow perch diet in the plume area consisted of higher frequencies of midges, isopods, amphipods and fish eggs than did perch at the nearby reference site, whereas crayfish were more important in perch diet at the reference site. It is suggested that these spatial differences in perch diet were due to differences in bottom habitat between the two locations.

(13) Some slight changes in perch diet were detected over the study period. Amphipods and midges have increased in importance since 1976, whereas the freqeuncy of mayflies in perch diet appears to have declined. The possible influence of the NTGS discharge in causing these changes was discussed.

(14) Rainbow smelt, smallmouth bass and white bass were shown to spawn in the NTGS discharge channel, but the importance of spawning activities here relative to other unaffected spawning areas in Long Point Bay is thought to be small.

(15) The Inner Bay and nearshore waters of Long Point were shown to be the most important spawning areas for many important fish species in Long Point Bay (eg. yellow perch and smallmouth bass). As most recruitment probably arises from this area, it is unlikely that observed fluctuations in year class strengths were related to industrial activities as this area is far removed (40 km) from industrial effluent.

(16) Fluctuations in yellow perch fecundity were shown to be circumstantially related to stock size, but no significant differences in fecundity between perch captured at Nanticoke and at reference areas were detected. It is unlikely that heated water discharged from the NTGS altered gonadal maturation patterns in yellow perch.

(17) Growth of yellow perch, rock bass, smallmouth bass and white bass was examined over the study period. Growth rates were shown to be typical or slightly faster in Lake Erie than in many other northern waters. An apparent decline in size-at-

age of perch over the study period was shown to be a lakewide phenomenon probably caused by selective commercial fishing.

Typical of most studies with similar design, the data base acquired during the course of our investigation was extensive. Nevertheless, in view of the lack of spatial and temporal homogeneity in our study area, and the strong variability in the parameters measured, the sampling design and/or sample sizes may not have been statistically adequate to demonstrate effects in some instances. Our sampling design clearly was inadequate to isolate effects due to a particular industry, although for most of the study period only the NTGS operated at levels sufficient to warrant concern. As the effluent from Texaco was mixed with that from the NTGS, separation of its effects from those of Ontario Hydro's discharge would have been largely impossible given the design of our study, and the parameters we monitored. Discharge from Stelco was significant only after 1982 and it is unlikely that changes in the fish community due to this effluent would be detected in our investigation. Concurrent monitoring of contaminant levels in several Long Point Bay fish species by MOE and IJC will be more apt to detect early effects of Stelco's and Texaco's discharge than would our study at the population level.

The principal concerns over the operation of the generating station were related to potential environmental effects of the heated water discharge and, later, to impingement and entrainment of fish drawn in with the cooling water. Specific studies relating to the effects of impingement and entrainment of fish were not within the scope of our 1980-1983 investigations because Ontario Hydro initiated its own series of investigations relating to these issues. Joint government-

Ontario Hydro working groups have been established to investigate the problem of fish impingement on a provincial scale, and specific studies related to alleviating fish impingement at the NTGS were carried out by Ontario Hydro during the 1980-1983 period (Balesic 1981, Wianko and Butler 1981, Wianko and Dixon 1983, Ellis 1984, Balesic 1986). Most recently, a joint government-Ontario Hydro task group has been examining the environmental costs and benefits of reducing tempering (and therefore station intake volume) at the plant as a means of reducing impingement. Early results suggested that the number of fish entrapped in the forebay was directly proportional to the volume of water drawn in by the plant. Thus, reduction of intake volume by reducing or eliminating tempering should reduce fish entrapment substantially. Potential enviornmental effects of elevated ΔT's at Nanticoke resulting from reduced tempering have been the subject of several recent studies carried out by Ontario Hydro. Studies of fish entrapment, impingement and entrainment at Nanticoke have shown that rainbow smelt is by far the most numerous species killed, followed by alewife and gizzard shad (Table 5.1). The effects of these losses are difficult to assess without good population estimates. Moreover, adult rainbow smelt were not vulnerable to the gear employed in our study; thus, we have no indices of trends in abundance for this species. However, examinations of commercial smelt harvests over the study period revealed no trend that could be related to power plant mortalities.

Perhaps the most significant influence by industry that we have detected has been the attraction by fish to the NTGS plume and the subsequent development there of a substantial sport fishery. Potential long-term effects of this development are difficult to predict, particularly in view of the change in plant operation (reduced tempering) near the end of our final year of field studies. The sport fishery at the plume developed only recently, and our monitoring program terminated too early to detect changes in the population structures as a result of the increased exploitation levels. At this point we can only draw on the work carried out by Shuter et al. (1985) who predict substantial changes in the smallmouth bass population at the BRUCE NGS as a result of increased vulnerability of bass to exploitation. While smallmouth bass are of less importance in the fishery at Nanticoke than at Bruce, the same scenario may develop here should the fishery persist or increase under the new operational regime. Presently, however, the sport fishery here is viewed by most as a positive development because it has increased sport fishing opportunities in an area little used by most anglers in the past. While angler CUE's of white bass are exceptionally high, we do not expect substantial changes in white bass populations as a result of this fishery because the population is extensive and wide-ranging in Lake Erie. There is no evidence that white bass appearing at the Nanticoke TGS are local stocks, and it is unlikely that they represent a significant proportion of the basin- or lakewide populations.

Our monitoring of the local fish community has revealed few substantial effects by industry on the variables we considered. Most of the influences we have noted are localized and confined to the thermal discharge area of the NTGS (ie. attraction by fish to the plume). The underlying problems we experienced in interpreting our data have been dealt with earlier in this report and, of course, the inevitable retrospective question is whether we monitored the correct variables: "Monitoring of the wrong variable can seem to indicate no change even when drastic change is imminent" (Holling 1982). It is, therefore, difficult to predict with certainty if future changes lie ahead, particularly because our program stopped before all industries had operated near capacity for an extened period of time, and because our program did not encompass operational changes at the NTGS initiated in 1983 (reduced tempering). Clearly, there has been no well defined "before and after" periods in our monitoring program; thus, our ability to forecast future changes (or lack of them) is restricted. We have presented our data and findings as clearly as possible, and strongly emphasize the need for ongoing assessment if we are to increase our understanding of the responses by the fish community to these industries. Key benefits from this report will be lessons for future environmental investigations. Much has been learned in the past decade regarding the response of fish to power plants, and a good retrospective analysis of this project, combined with subsequent re-directed monitoring, will contribute considerably to the process of designing future assessment programs.

The fish community of Long Point Bay has experienced several changes since the beginning of this study. Recently, the rainbow smelt population has exhibited signs of stress and, by 1986, only one year class (1984) dominated the fishery. Strong fluctuations in year-class strengths of yellow perch have been typical of the population in recent years - the strong 1982 year class was followed by an extremely weak one in 1983 which, in turn, was followed by a strong 1984 year class and then by a relatively weak 1985 year class. The recent lakewide expansion of the walleye population in the western basin apparently has lead to a modest return of the species to Long Point Bay, and white perch are now common in these waters, whereas the population was almost non-existent in Long Point Bay prior to 1980. Since 1979, Pink salmon have been important in the bay when odd-year runs make a strong presence at the mouths of several streams in September. Such changes demonstrate the dynamic nature of fish communities and the problem future long-term studies of similar design can expect to face. All of the above are changes that have occurred coincidentally during or shortly after the operational phase of the project, and yet none are due to the effects of industry. Extreme caution in interpreting pre-operational versus operational data clearly is a requirement in such studies. In study areas such as ours, where the system is not closed and where other stresses (eg. commercial fishing, sport fishing etc.) are common, variable in their effect, and significant in comparison with the effects to be measured, preoperational fisheries data will unlikely represent even a quasi-control situation.

On the basis of our data and information in relevant literature, we can predict no major changes in the fish community as a direct result of industry, beyond the development and persistence of the sport fishery at the plume. The future of the fish community of Long Point Bay apparently is much more strongly dependent on the commercial fishing industry, sport fishing and environmental quality of important spawning and nursery areas such as the Inner Bay. These would appear to be the key management concerns in protecting and maintaining the fisheries resources. Stresses such as over-exploitation, deteriorating water quality and reduction of marshland for marina development will produce major changes in the fish community if not managed with diligence. Presently, any additional stresses imposed by industry do not appear to be severe, but we view the results of our study as only interim. Future monitoring under fully operational conditions will be required, particularly with respect to the discharge from Stelco. Contaminant levels in fish will require continued monitoring and perhaps these studies must be escalated to more specifically examine the levels in relation to industrial discharge. The sport fishery at the NTGS and its effects will require continued monitoring, and efforts to better identify important spawning areas in Long Point Bay are essential to the understanding and protection of the fish community. Present knowledge of fish reproduction in Long Point Bay and sources of recruitment is woefully inadequate for all species, beyond our limited information for the Inner Bay.

In conclusion, while our investigation has contributed considerably to scientific knowledge of certain aspects of the fisheries in Long Point Bay, it has yielded little in a predictive sense. Given the current status of environmental science we must expect the unexpected. Clearly, the provincial importance of this fishery, and the stresses imposed on it, demand that surveillance and assessment of the fish populations become a routine. In addition, a strong examination at the community level would contribute considerably to our understanding of the resource and hopefully to our predictive capability. Of particular concern are the factors governing the strengths of year classes; present information would suggest that these factors are largely due to environmental conditions during their first growing season. Given the recent strong fluctuations in year class strengths of several local fish species, more attention to identifying these factors would appear to be crucial to improving our predictive capability.

Table 5.1. Annual fish losses at the Nanticoke Thermal Generating Station (adapted from Wianko (1981).

| Species | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 |
|---|---|---|---|---|---|---|---|---|---|---|
| Numbers of fish impinged:* | | | | | | | | | | |
| Alewife and Gizzard shad | 700 | 57500 | 32800 | 22100 | 5000 | 4400 | 284681 | 88328 | 82207 | 109838 |
| Rainbow smelt | 400 | 62500 | 47000 | 53100 | 165400 | 782000 | 591194 | 127640 | 402345 | 490946 |
| Spottail and Emerald shiners | 113 | 457 | 913 | 86 | 166 | 2100 | 2027 | 155 | 56885 | 22952 |
| Carp | 10 | 5 | 3 | 11 | 3 | 11 | 11 | 22 | 18 | 18 |
| White sucker | 4 | 6 | 1 | 5 | | 13 | 2 | 6 | 8 | 18 |
| Channel catfish | 63 | 17 | 49 | 69 | 45 | 22 | 29 | 44 | 18 | 25 |
| White bass | | 3 | | 82 | 13 | 31 | 142 | 3229 | 151 | 268 |
| Smallmouth and Largemouth bass | | 215 | 59 | 18 | | 12 | 12 | 22 | 44 | 131 |
| Rock bass | 17 | 44 | 160 | 695 | 82 | 114 | 1184 | 186 | 162 | 248 |
| Pumpkinseed | | 38 | 6 | 19 | 3 | | 111 | 29 | 29 | 8 |
| Yellow perch | 400 | 640 | 930 | 1130 | 850 | 3050 | 2867 | 1087 | 1287 | 1737 |
| Freshwater drum | 26 | 256 | 143 | 91 | 270 | 236 | 291 | 204 | 350 | 749 |
| Total | 1733 | 121681 | 82964 | 77406 | 171832 | 791989 | 882551 | 220952 | 543504 | 626938 |
| Estimated total fish losses ($10^3$ kg), impingement and tempering pumps: | | | | | | | | | | |
| | 1.47 | 30.16 | 21.77 | 22.86 | 35.04 | 69.61 | 87.98 | 31.63 | 45.90 | 111.11 |
| Station water flow ($10^9 m^3$), cooling and tempering: | | | | | | | | | | |
| | 0.8 | 2.0 | 2.3 | 2.3 | 2.6 | 2.2 | 2.6 | 3.1 | 3.6 | 3.1 |
| Total fish losses (mg) per 1 $m^3$ of station cooling water flow: | | | | | | | | | | |
| | 1.8 | 15.1 | 9.9 | 9.9 | 13.5 | 31.4 | 33.8 | 10.2 | 12.8 | 35.8 |

* includes only fish impinged on CCW travelling screens. To estimate total station mortality including tempering pump losses multiply totals by 10. (Wianko, 1981)

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